Satellite Meteorology

Geostationary Imaging and Sounding

Part II

Describe Geostationary Imaging

And Sounding With an Emphasis on GOES

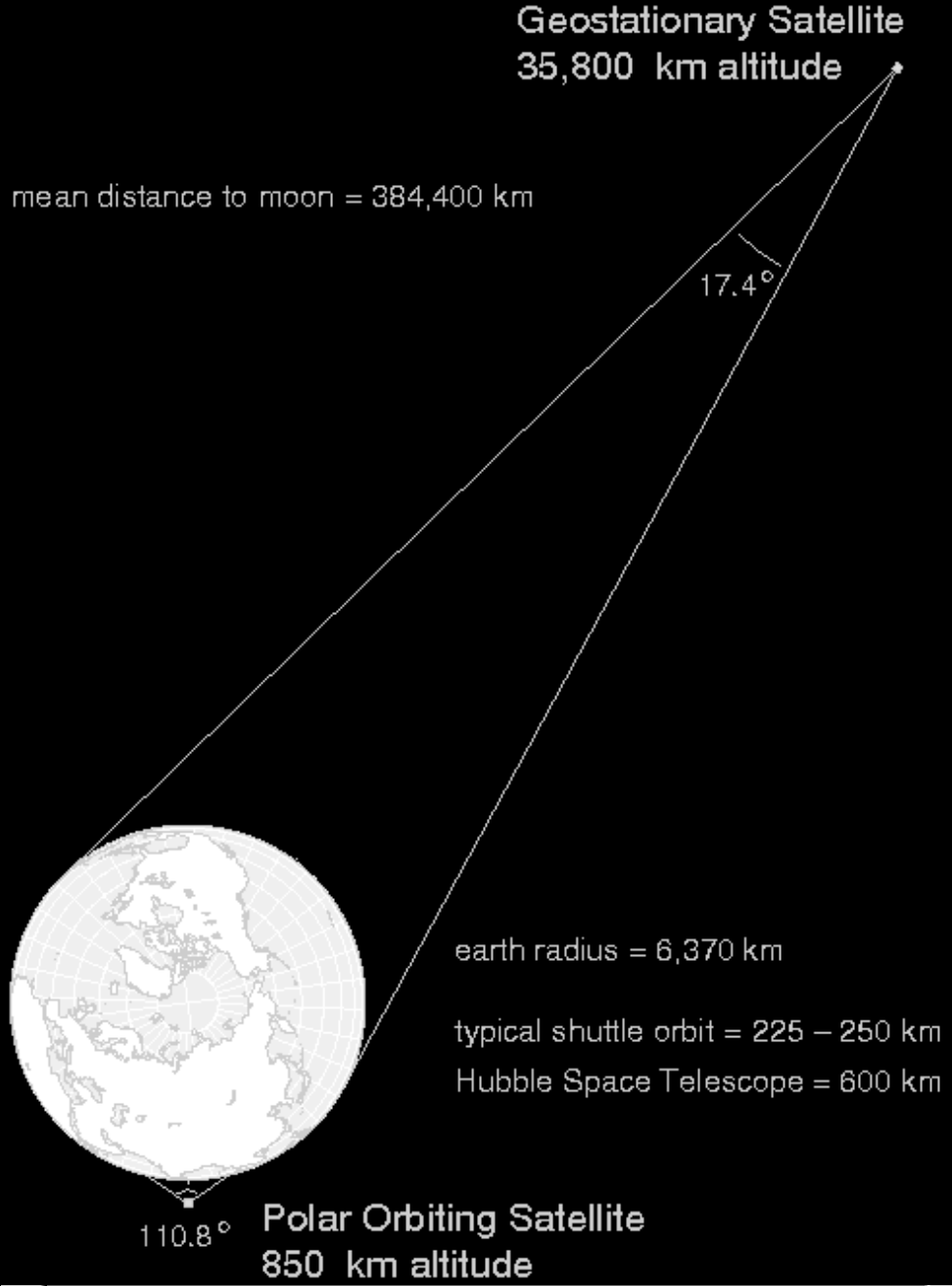
Objective

Describe geostationary imaging

And sounding with an emphasis on GOES

Geostationary

- Characteristics
  - Altitude
  - Orbit configuration
  - Spatial resolution
- Operational satellites
- Goes
  - Imager
  - Sounder


Geostationary Satellite
35,800 km altitude
mean distance to moon = 384,400 km
17.4°
earth radius = 6,370 km
typical shuttle orbit = 225 – 250 km
Hubble Space Telescope = 600 km
110.8°
Polar Orbiting Satellite
850 km altitude

Orbit Configuration

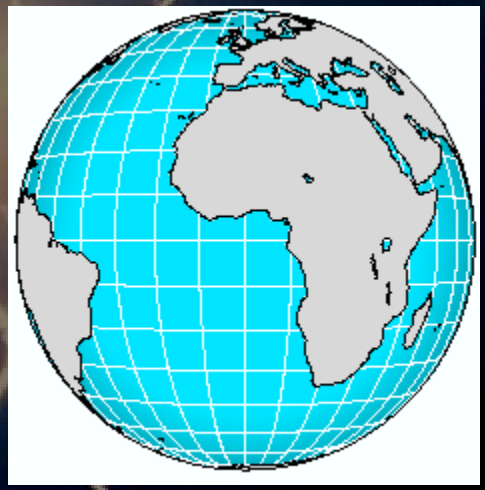
- Over the equator at a specific longitude
- Can be moved to a new longitude
- Stationary with respect to the earth
- Much higher altitude (lower spatial resolution) compared to low-earth orbiters
- Restricted to visible and infrared wavelengths
- Wonderful at the equator; Useless over the poles

Major Geostationary Platforms

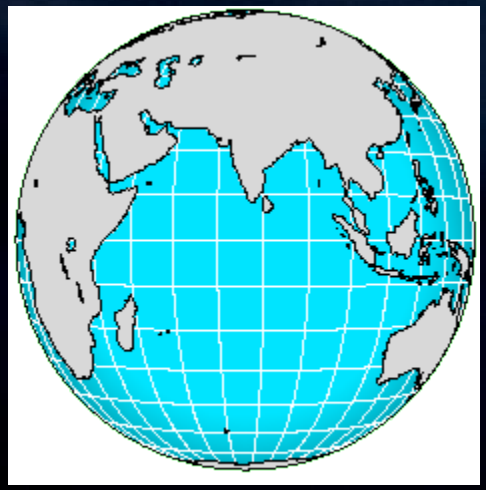
- GOES
  - 8 East Coast
  - 10 West Coast
  - 11 Standby
  - 12 (To replace GOES 8 on March 31, 2003)
- METEOSAT 5/6/7 – Europe/Middle East
- GMS 5 – Japan
- GOMS – Russia
- INSAT – India

Geostationary Meteorological Earth Satellite Views

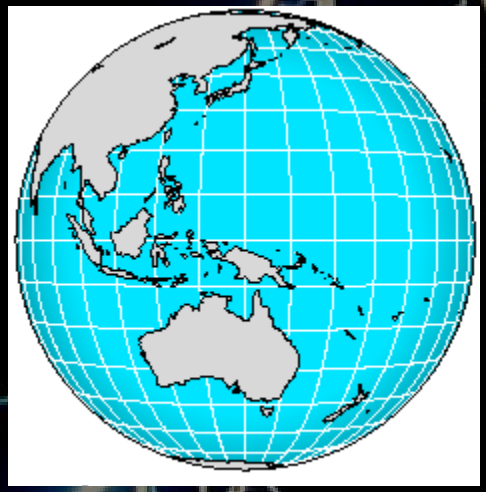
75 West GOES-8
United States



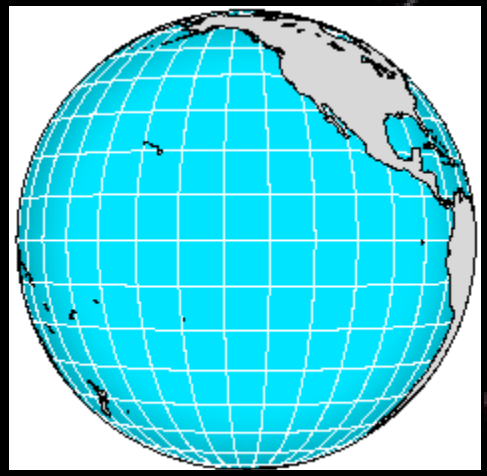
0 East
Meteosat-7
European



63 East Met-5
European



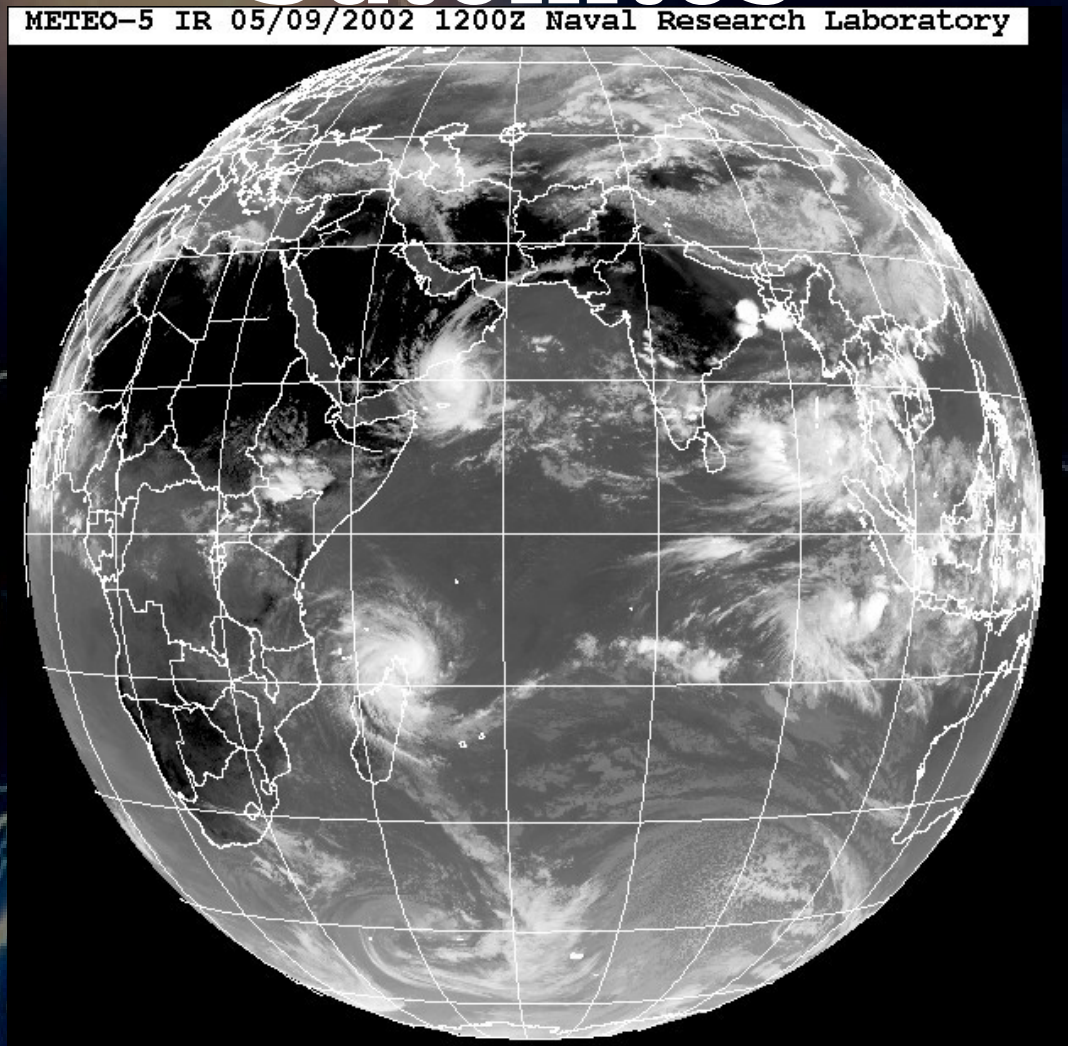
140 East GMS-5
Japanese



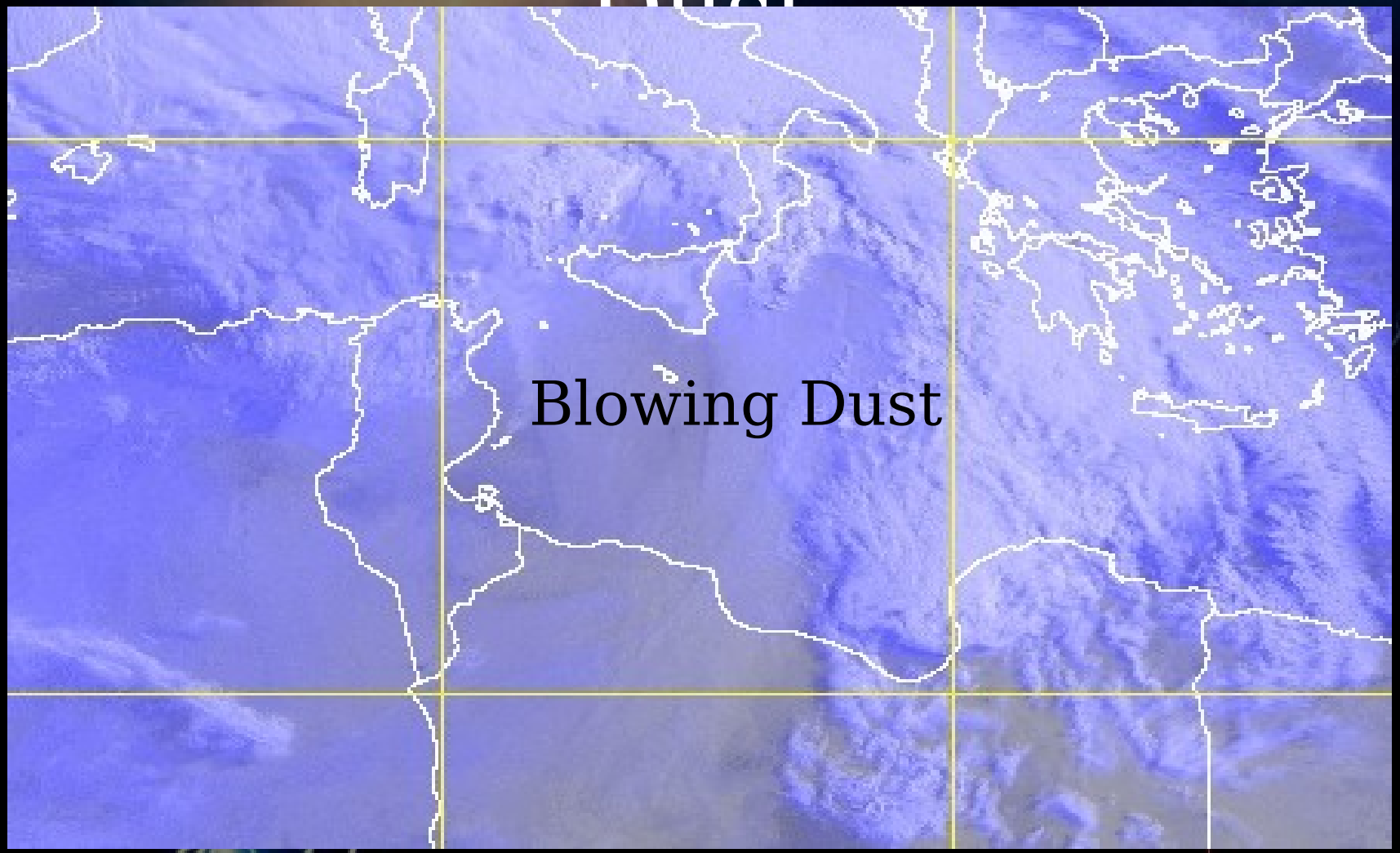
135 West GOES-10
United States

Images adapted from David Johnson, NCAR, Boulder, CO

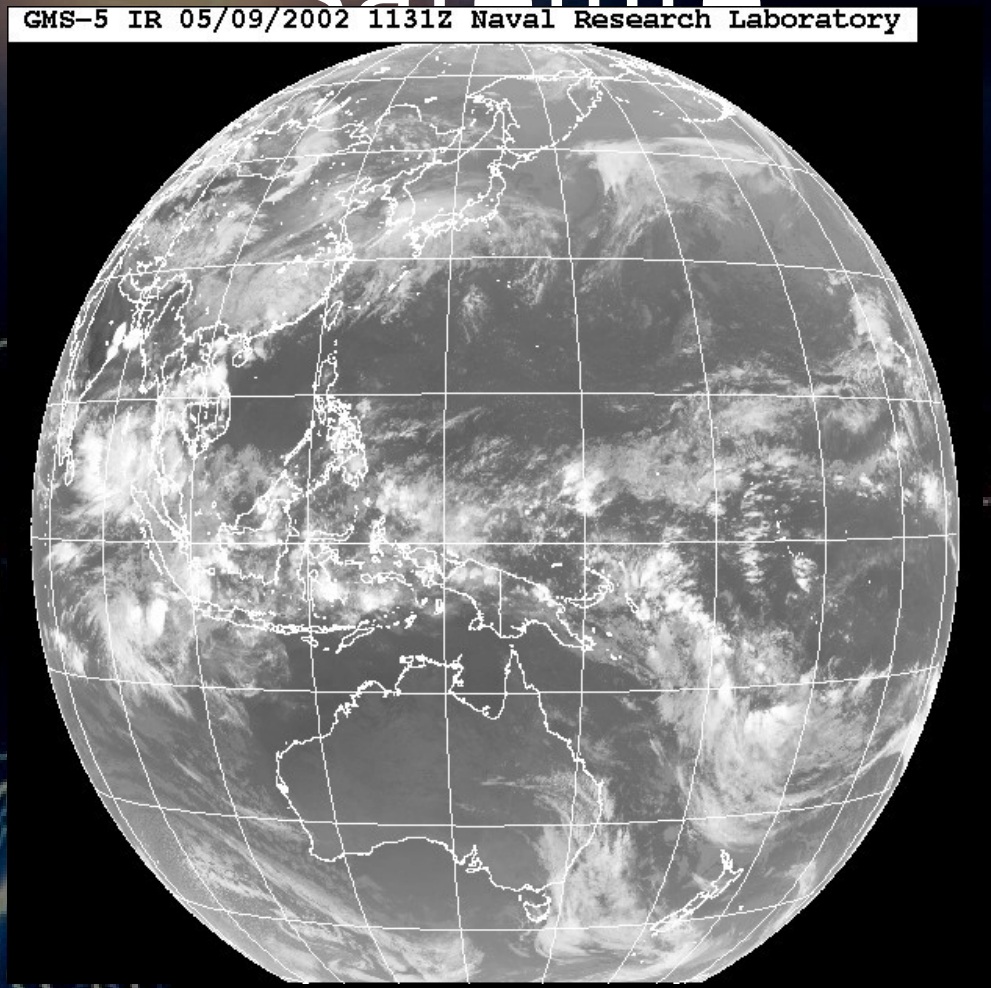
METEOSAT Geostationary Satellites



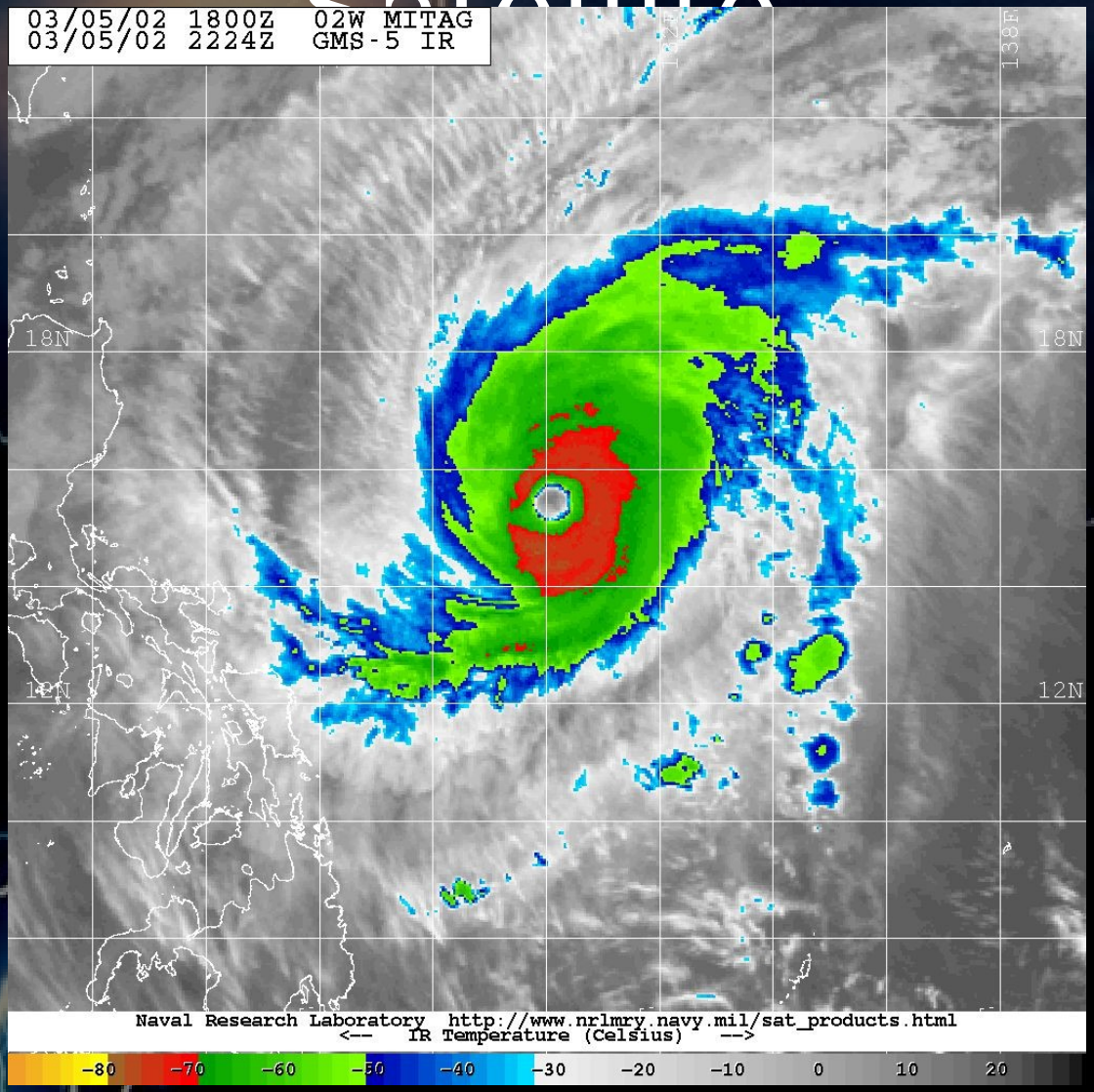
METEOSAT 7: African Dust



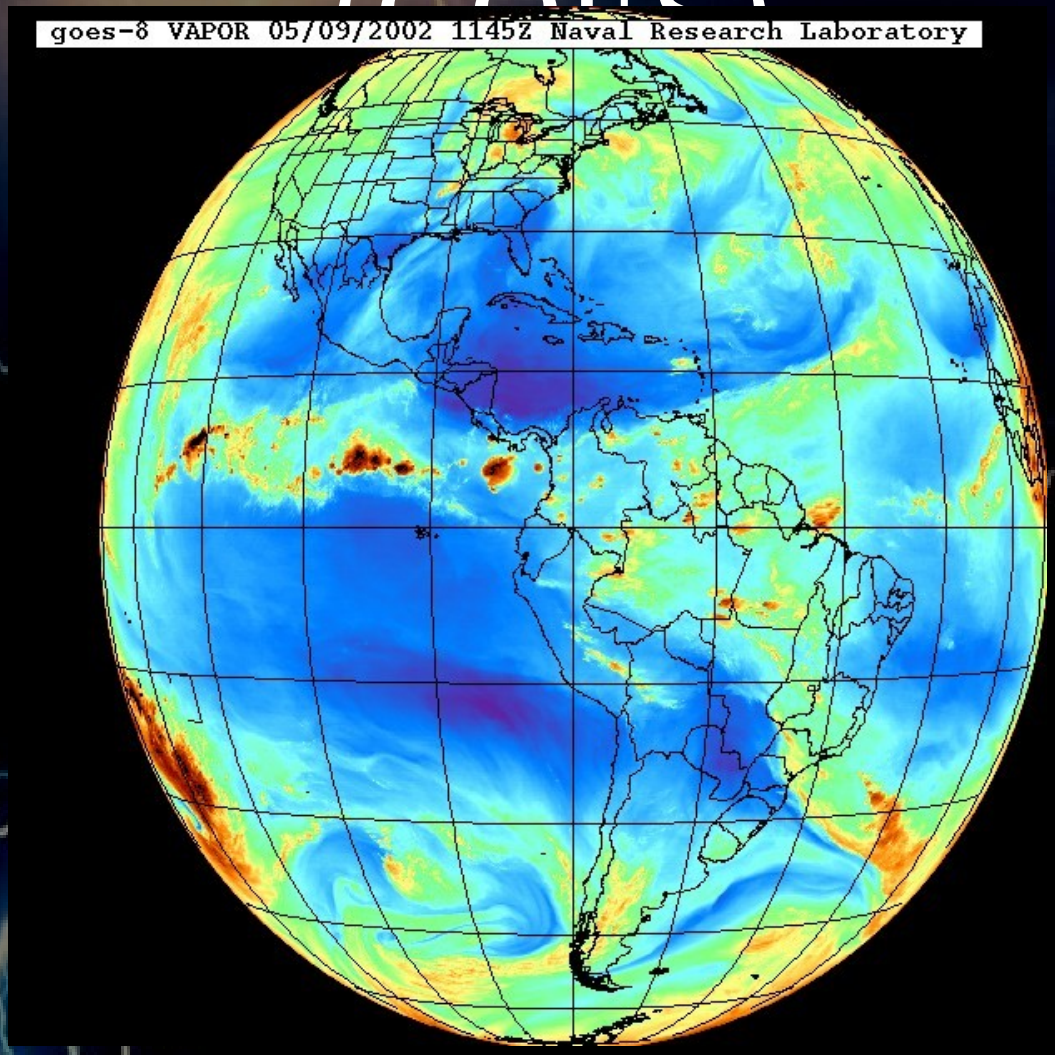
GMS Geostationary Satellite



GMS Geostationary Satellite



Geostationary Orbiting Environmental Satellite (GOES)



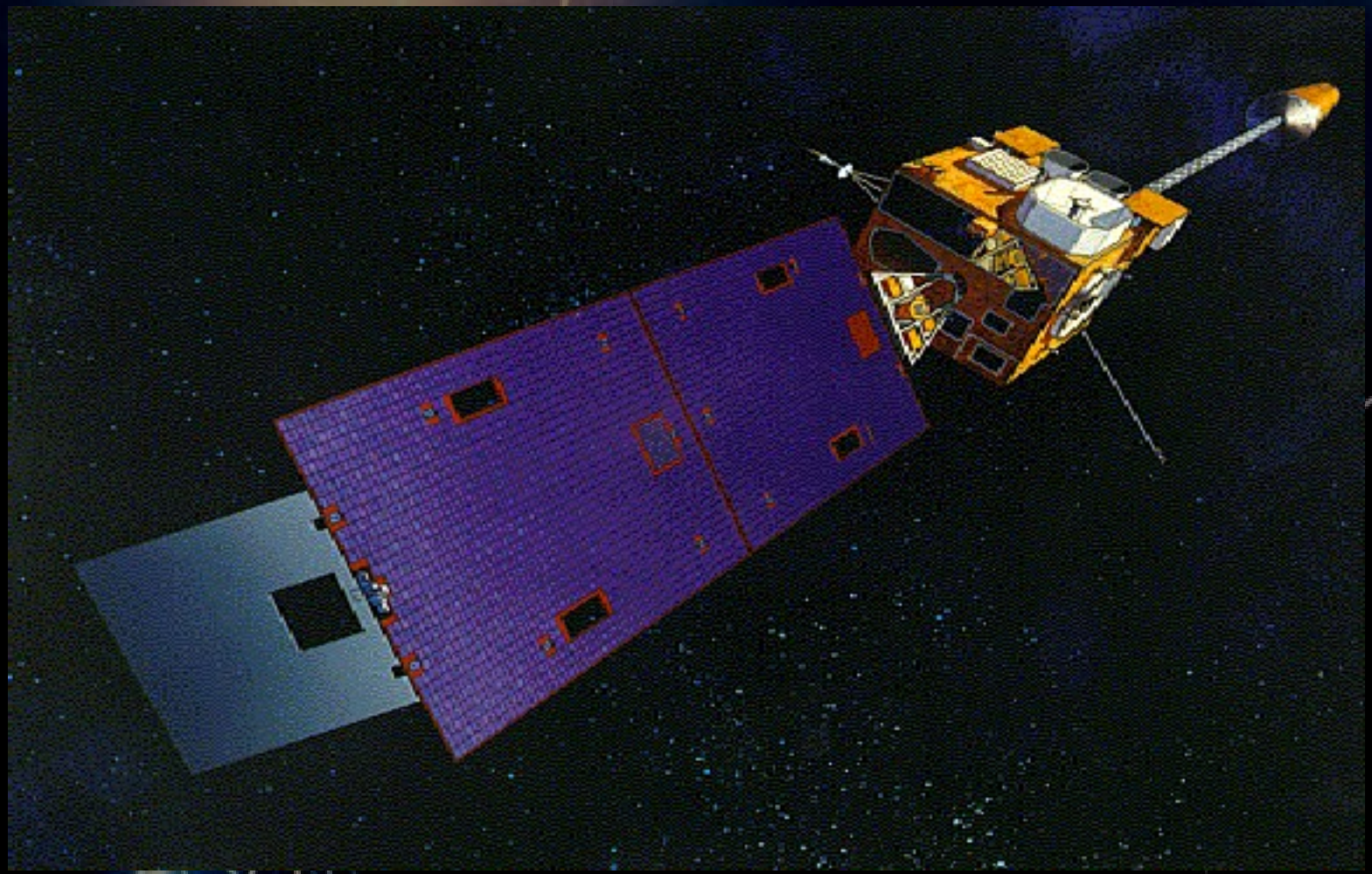
GOES 8/10/11/12

- Imager and Sounder
- GOES as an Imager
  - Channels – footprints, examples
  - Terms
  - Products
- GOES as a Sounder

Imager and Sounder

- Imager
  - 5 channels for producing images of weather systems
  - Imager more useful to forecasters than sounder
- Sounder
  - 19 channels producing vertical temperature and moisture profiles
  - Useful for products and model assimilation
  - Raw data rarely seen my forecasters

GOES Imager



Characteristics of GOES Imager

- Produces imagery by the use of a sensor
  - Visible, Infrared, Water Vapor
- Measures albedo in the visible channels and brightness temperature in the infrared channels

Characteristics of GOES Imager

- GOES 8/10/11/12 imagers
  - Always point towards the earth (3 axis stabilized system)
  - Previous sensors spun, causing a loss of data
  - The sensor sweeps east-west on one scan line, then west-east on the next
  - It does not take a photograph, though it looks like one

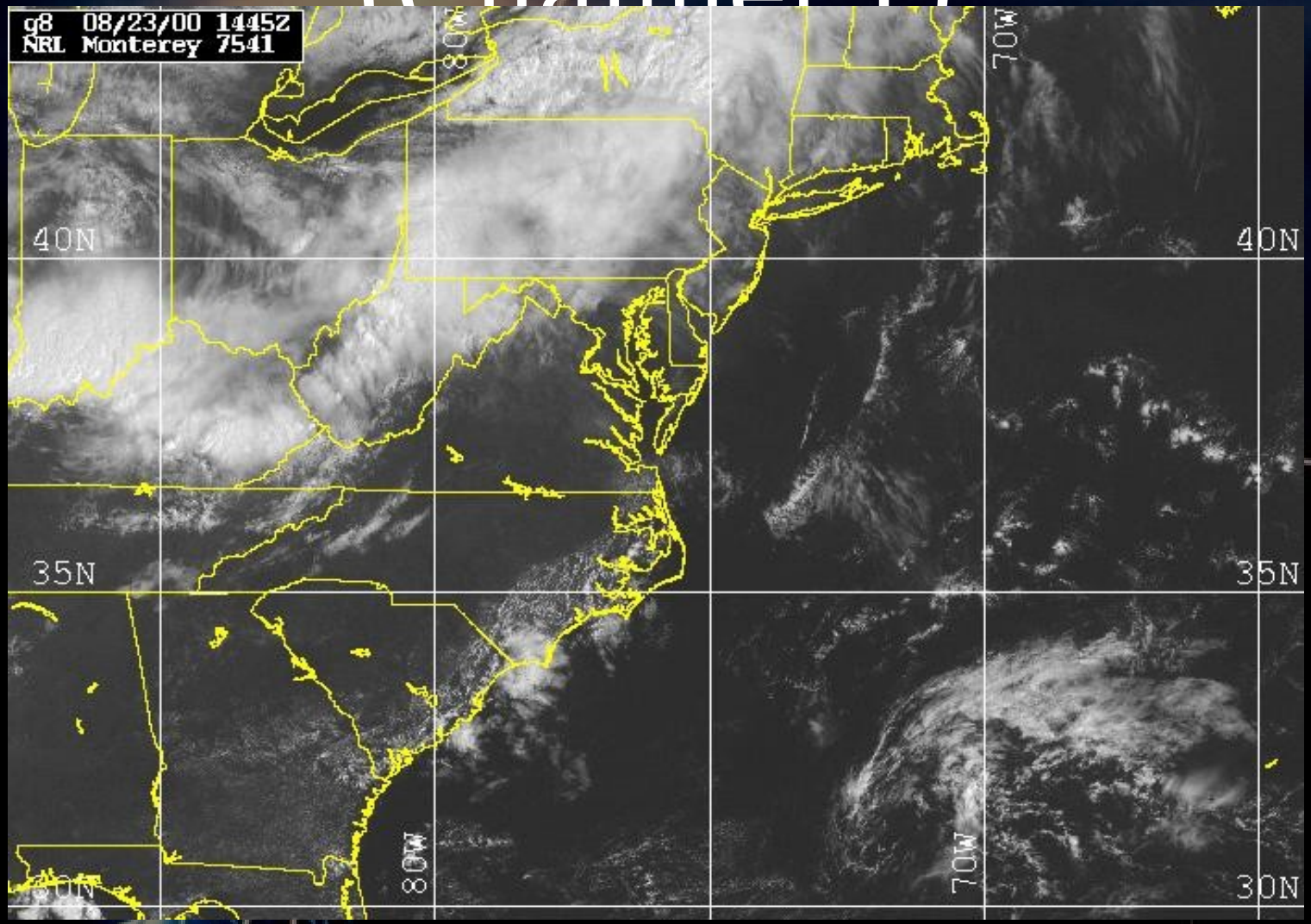
GOES Imager Channels

- Imager channels
  - **CH 1** - Visible 0.7μm
  - **CH 2** - Near IR, **shortwave IR**, low cloud channel 3.9 μm
    fire channel
  - **CH 3** - Water Vapor 6.7 μm
  - **CH 4** - Thermal IR, **longwave IR**, window channel 10.7 μm
  - **CH 5** - Thermal IR, longwave IR, split window, 12.0 μm
    "dirty" window

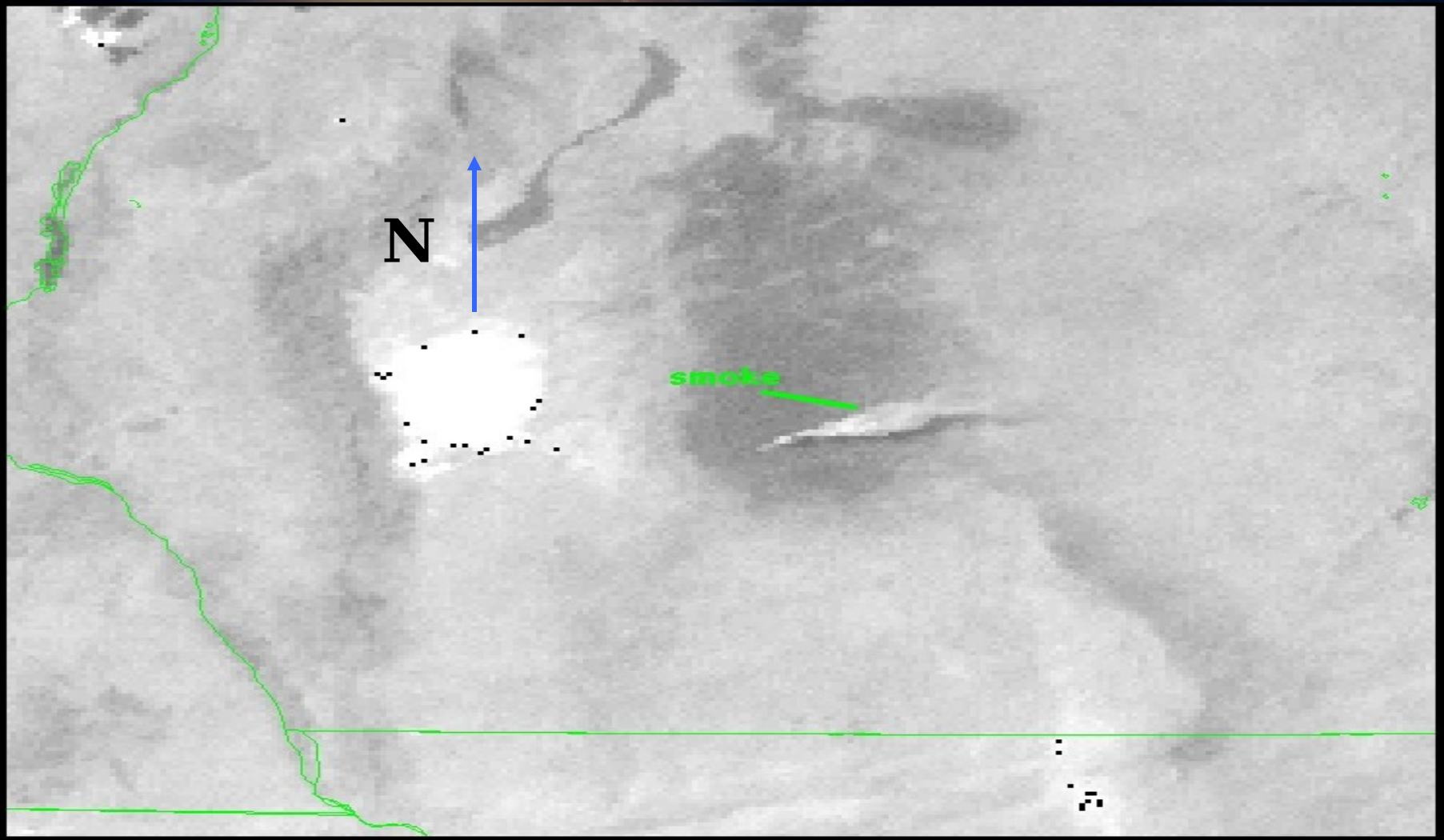
GOES Multi-spectral Imager: Wavelength and Footprint Size

- Channel 1 .6 micron .57 x 1 km
- Channel 2 3.9 micron 2.3 x 4 km
- Channel 3 6.7 micron 2.3 x 8 km
- Channel 4 10.7 micron 2.3 x 4 km
- Channel 5 12.0 micron 2.3 x 4 km

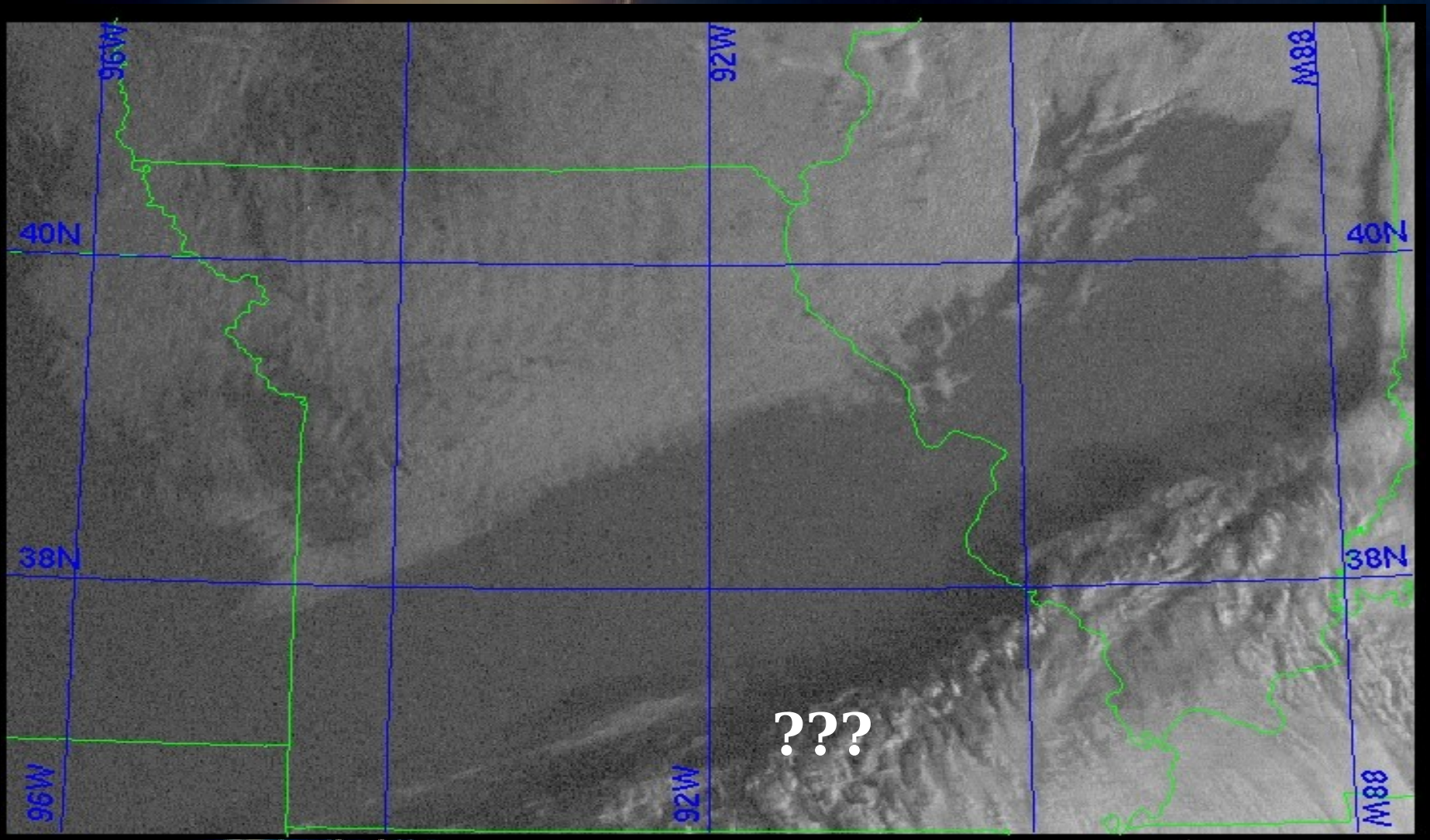
GOES Visible Shot (Channel 1)



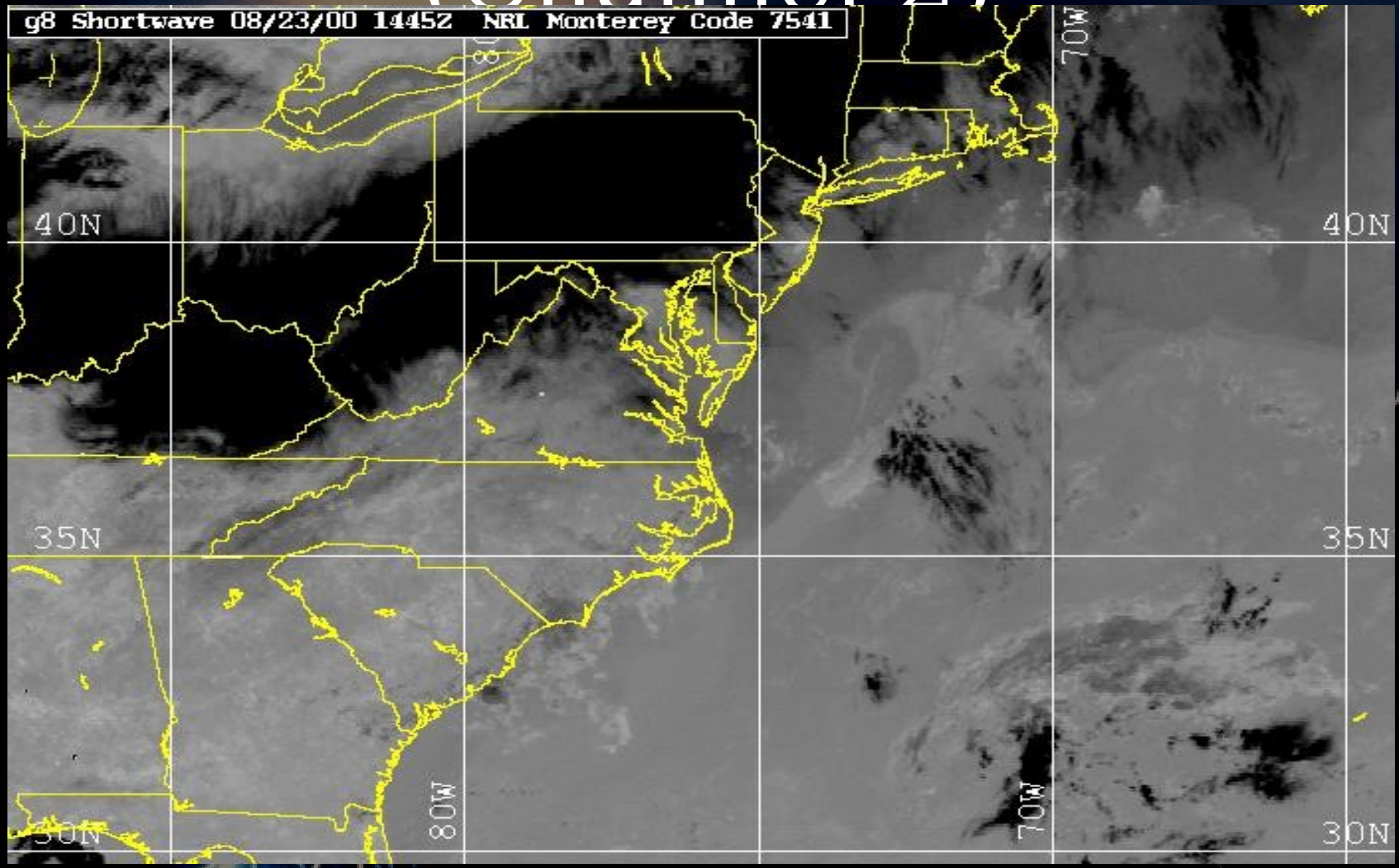
Visible Zoom shows High Resolution



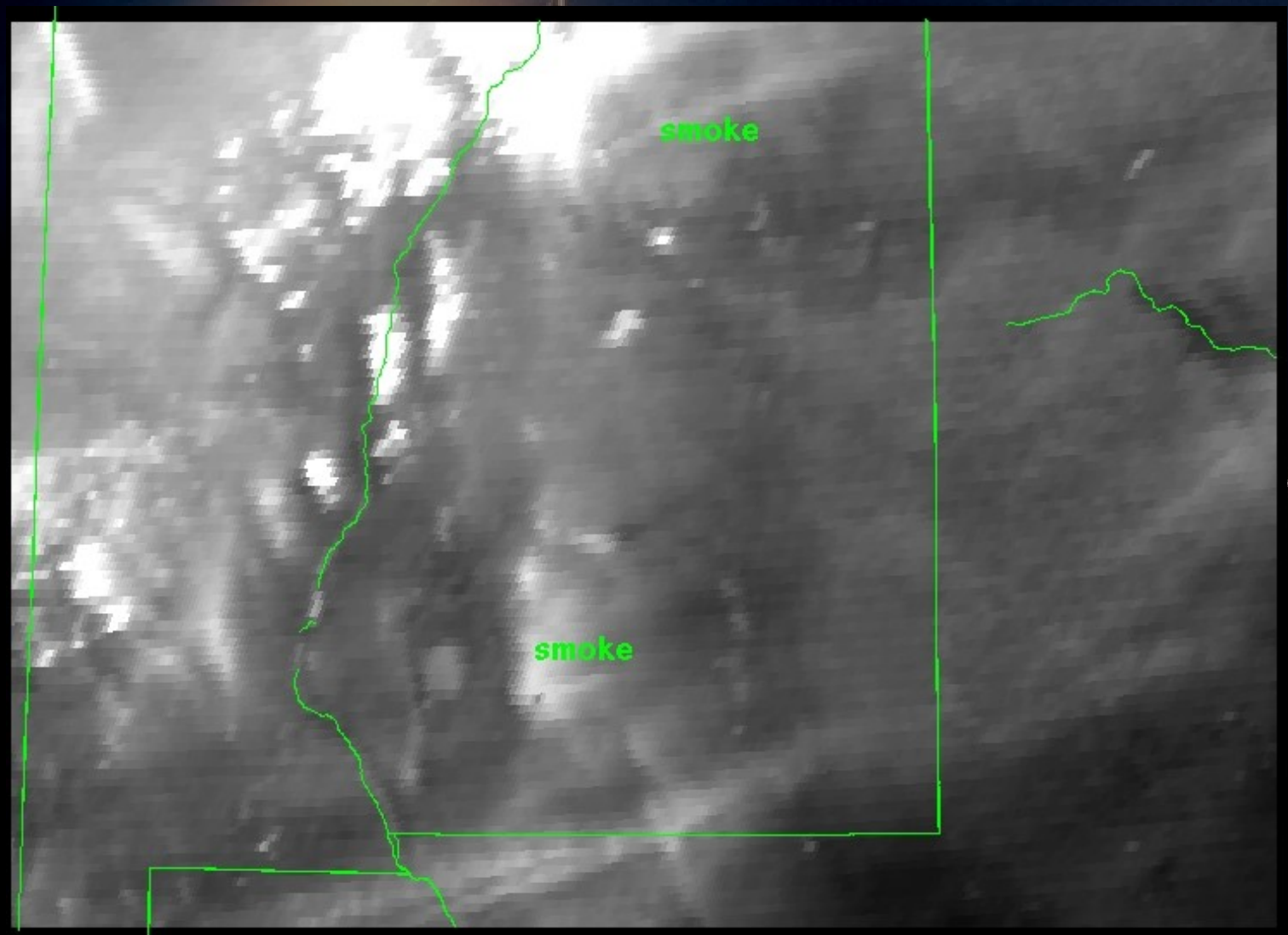
Visible Image Enhanced



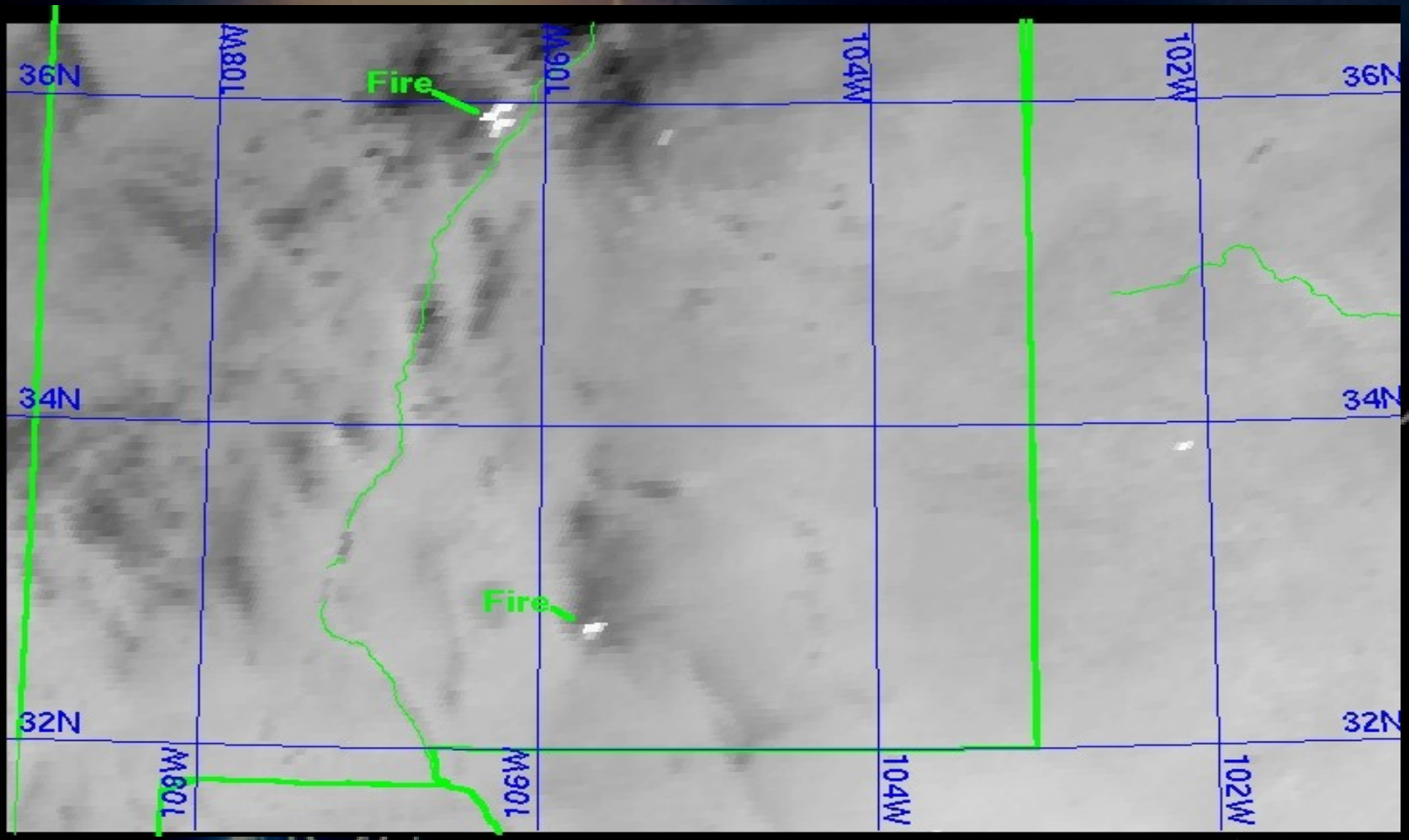
GOES Shortwave IR (Channel 2)



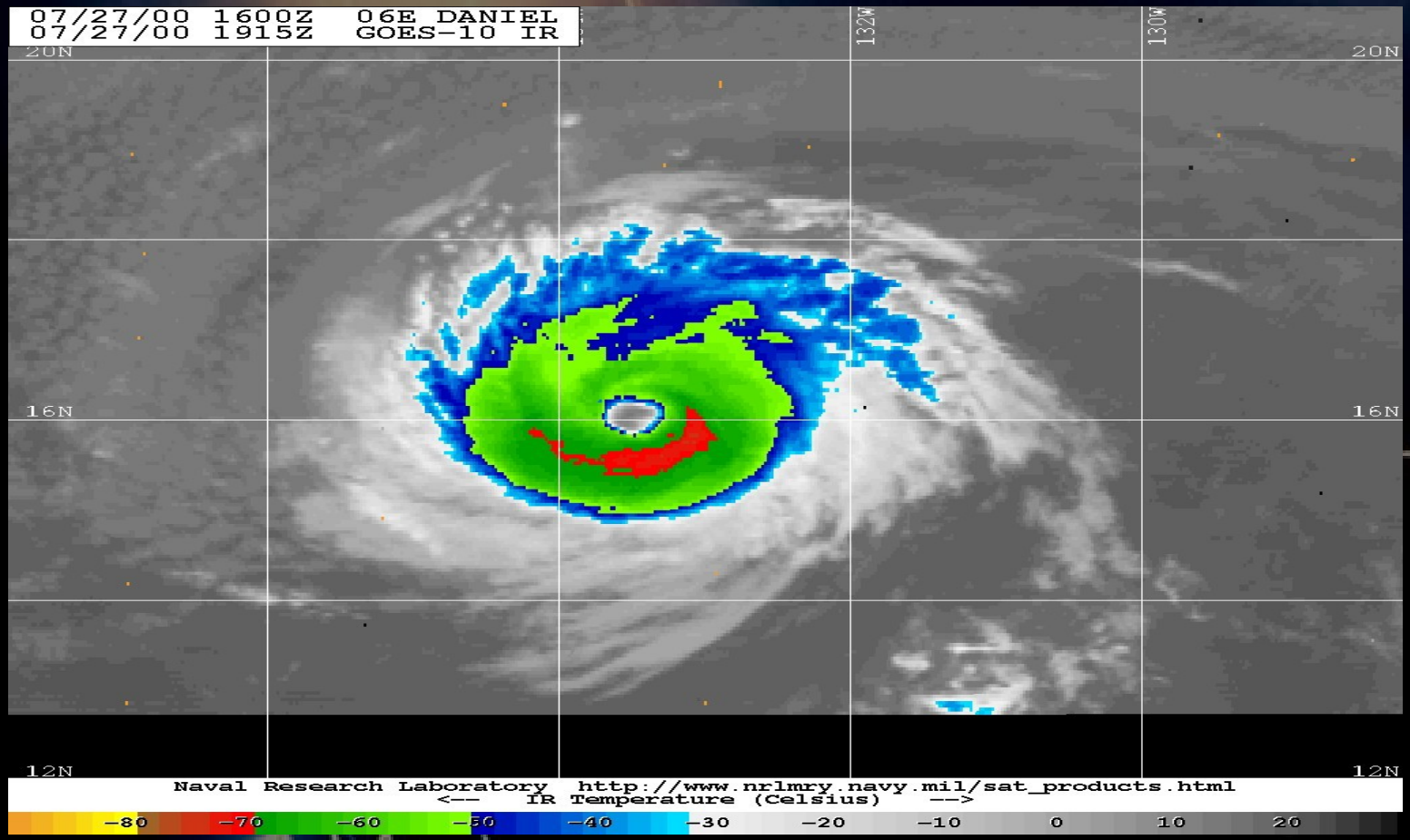
IR Sees Smoke



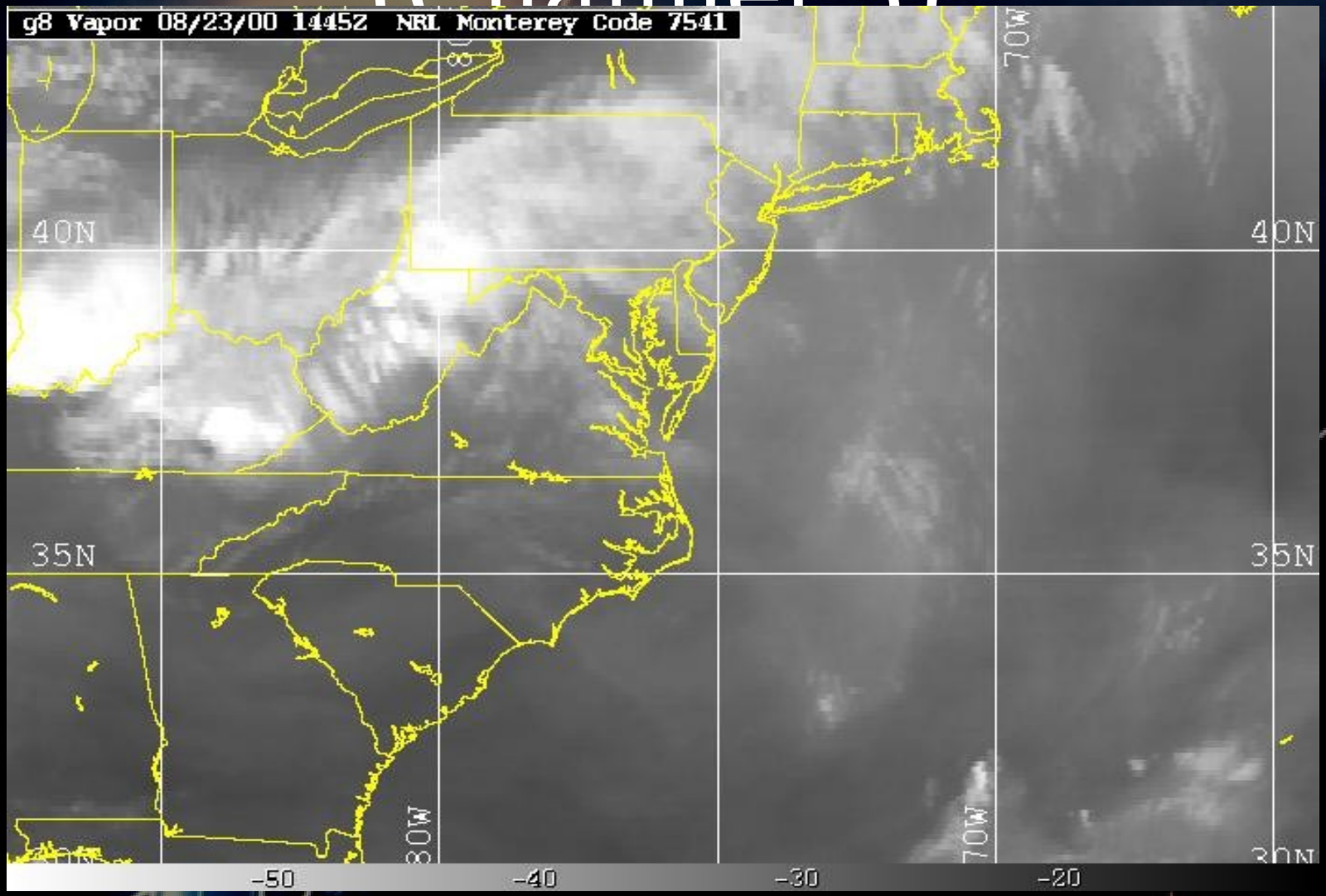
Shortwave IR shows Fires



Hurricane Daniel Colorized IR

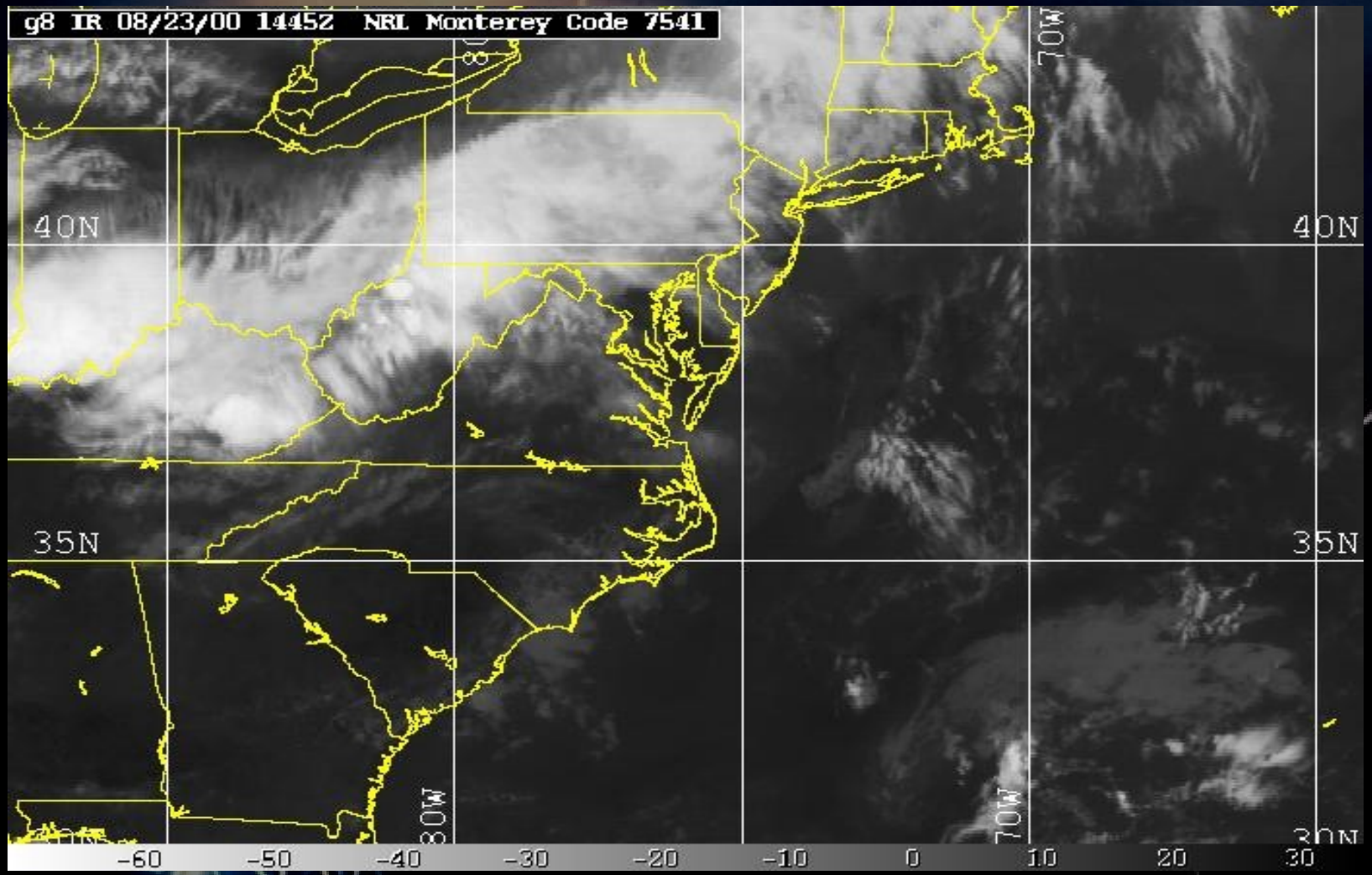


GOES Water Vapor (Channel 3)

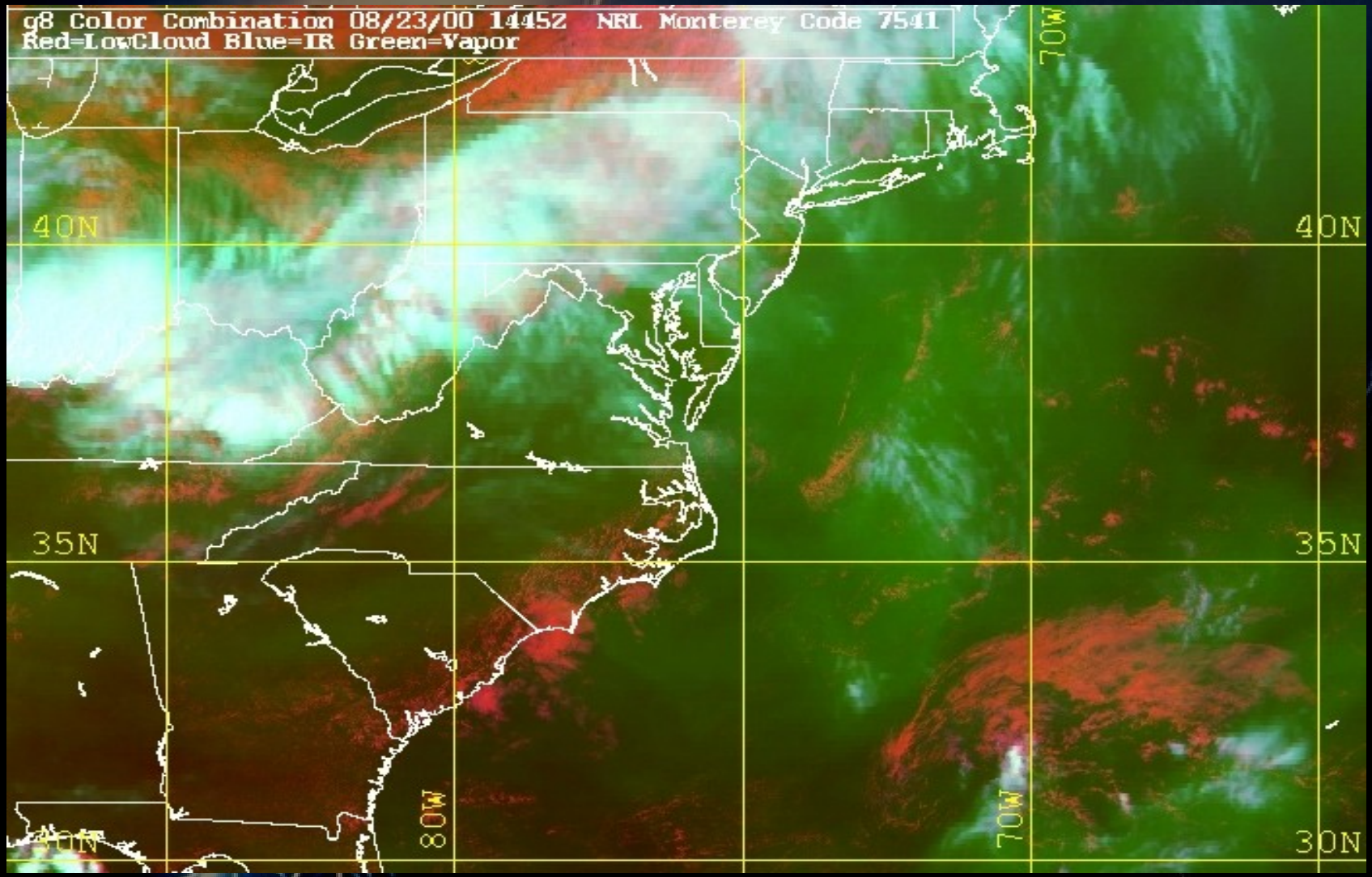


GOES IR Shot (Channel 4)

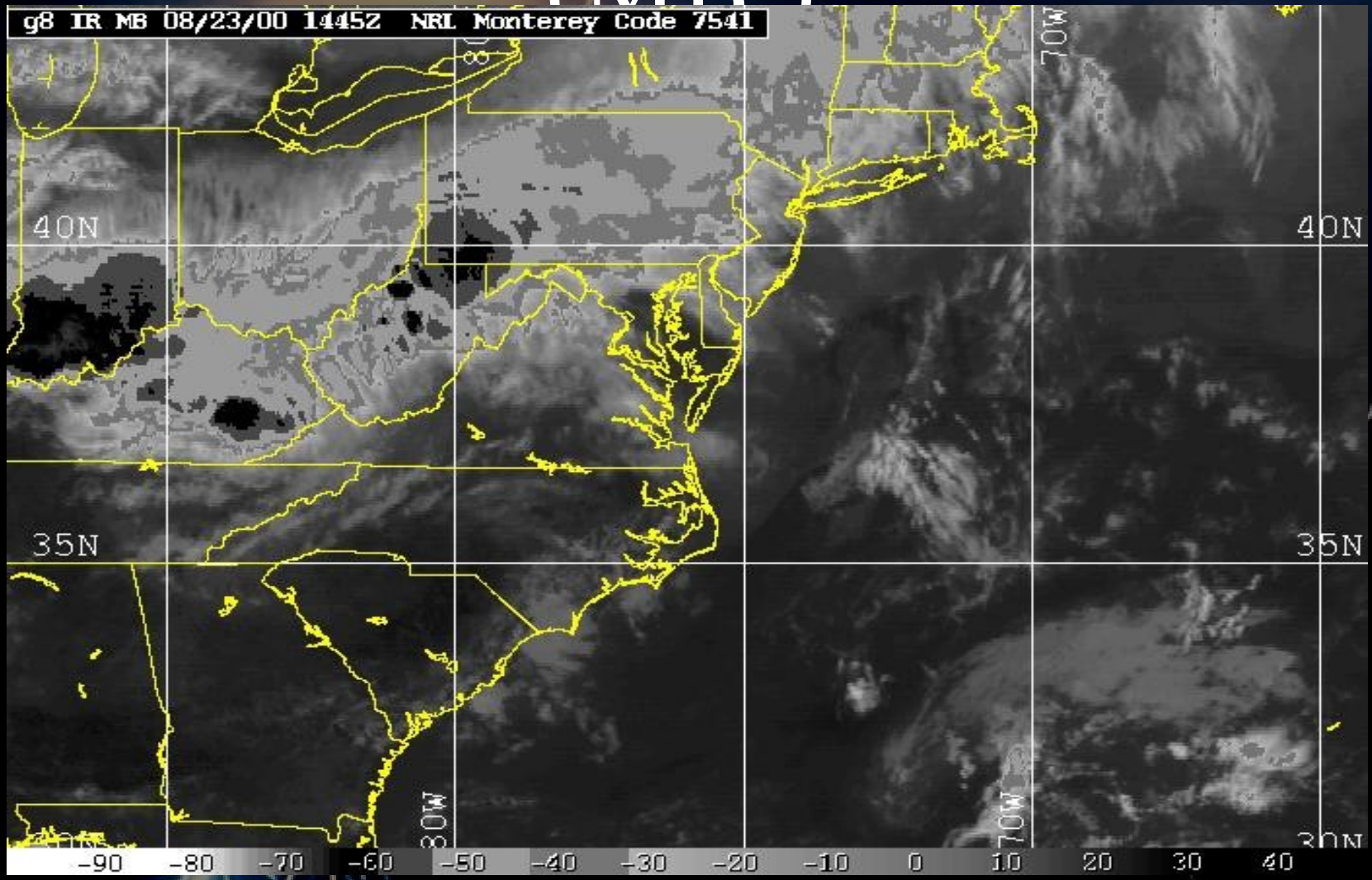
GOES IR Shot (Channel 5)



GOES Color Combination



GOES IR Enhancement (MB)



Imagery Terms

- WEFAX – Term refers to an image that is preformatted, including boundaries. Unable to alter WEFAX imagery
- GVAR – GOES I-M Variable data transmission format. Generally refers to high resolution imagery. Can perform math functions
- PDUS – Primary Data User Station. Telemetry (associated with high resolution digital data)

http://www.sat.dundee.ac.uk/pdus

Products

- High Density Winds
- Low Cloud Product
- Stitched Imagery
- Severe Weather Identification
- Storm Signatures
- Obstructions to Vision

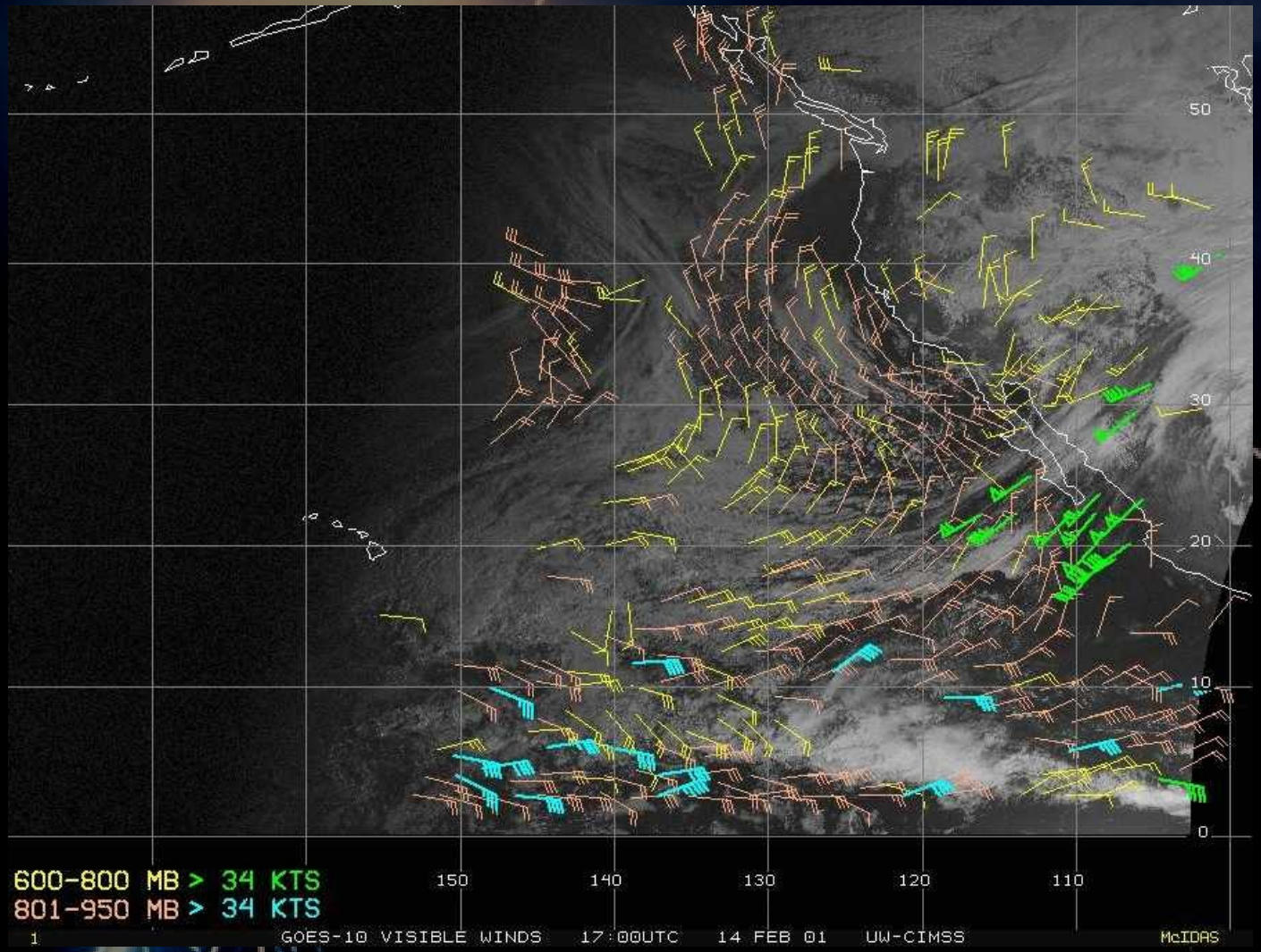
GOES Imager
High Density Winds

- Product explanation
- Visible winds
- Cloud drift IR winds
- Water Vapor winds
- Advantages and Disadvantages

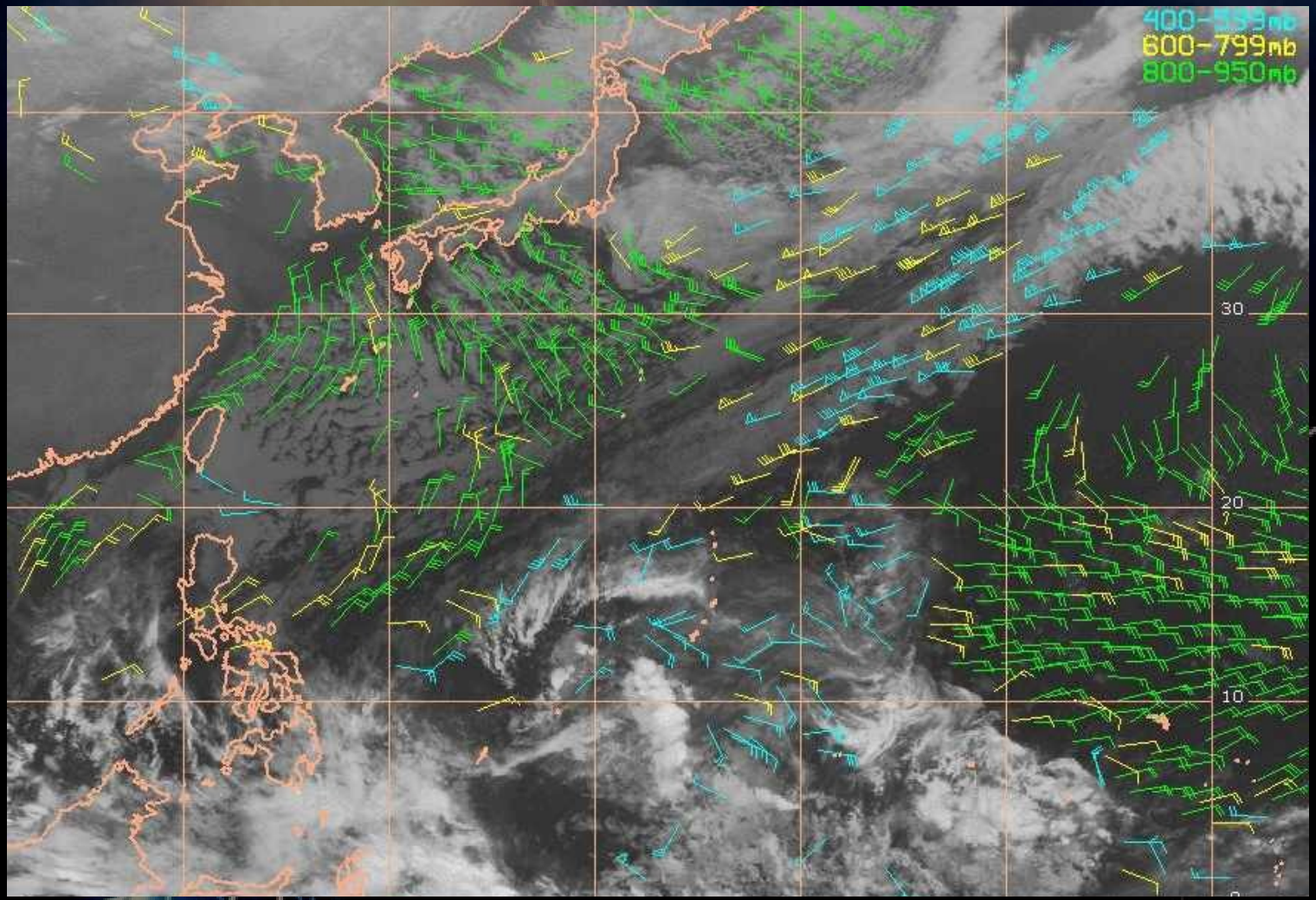
Geostationary Winds: How they do it.

- 3 successive images 30 min apart
- Drift winds:
  - Low level clouds are tracked, vector differences are derived. There must be clouds for the sensor to “target”
- Water vapor:
  - Water vapor gradients are tracked

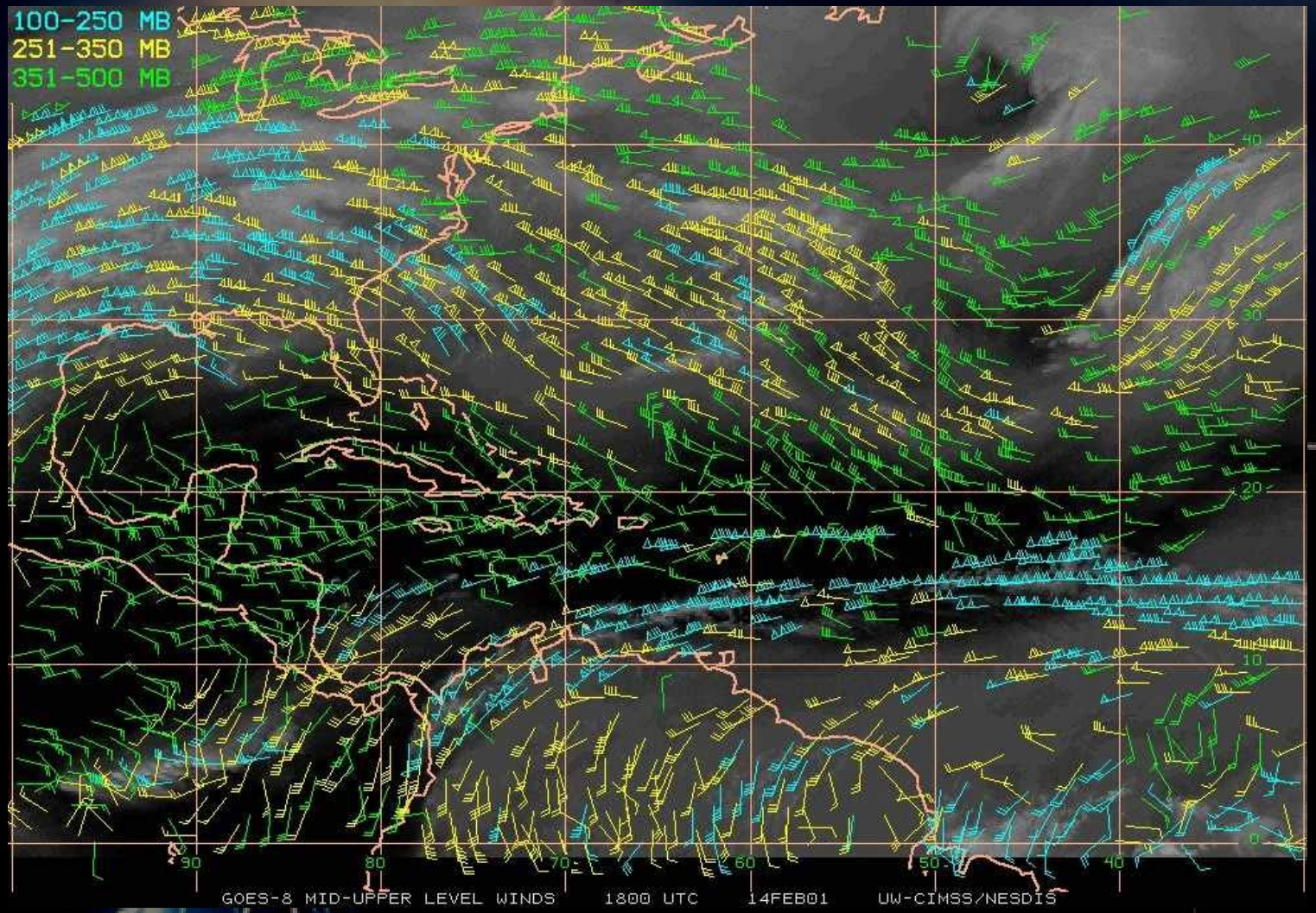
Visible


50
40
30
20
10
0
600-800 MB > 34 KTS
801-950 MB > 34 KTS
150
140
130
120
110
1
GOES-10 VISIBLE WINDS 17:00UTC 14 FEB 01 UW-CIMSS
McIDAS

Infrared

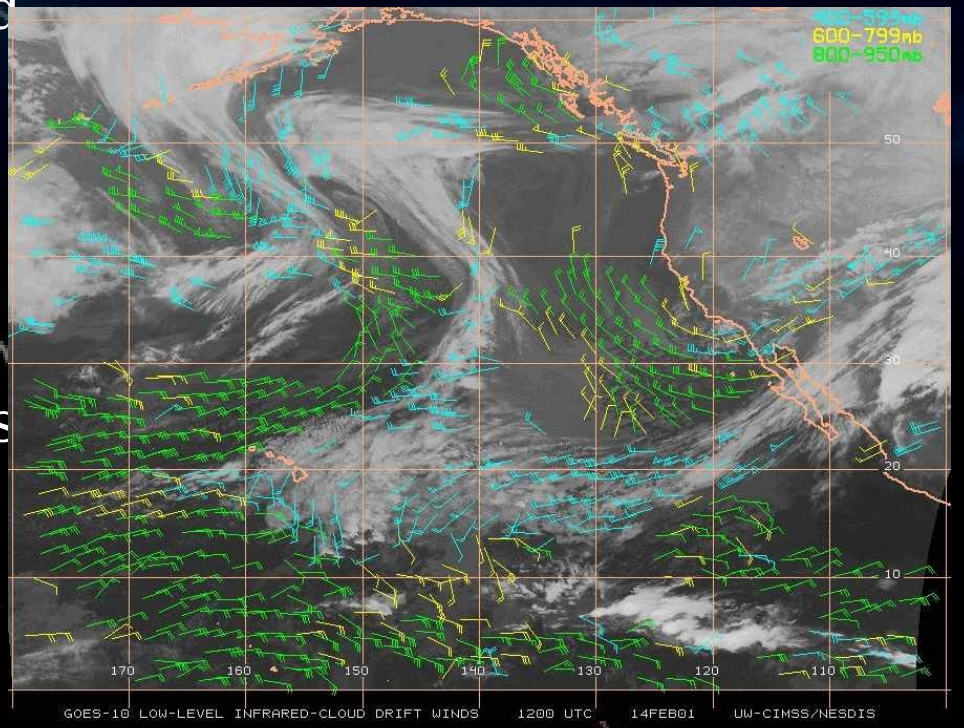


Water Vapor


100-250 MB
251-350 MB
351-500 MB
90
80
70
60
50
40
30
20
10
GOES-8 MID-UPPER LEVEL WINDS 1800 UTC 14FEB01 UW-CIMSS/NESDIS

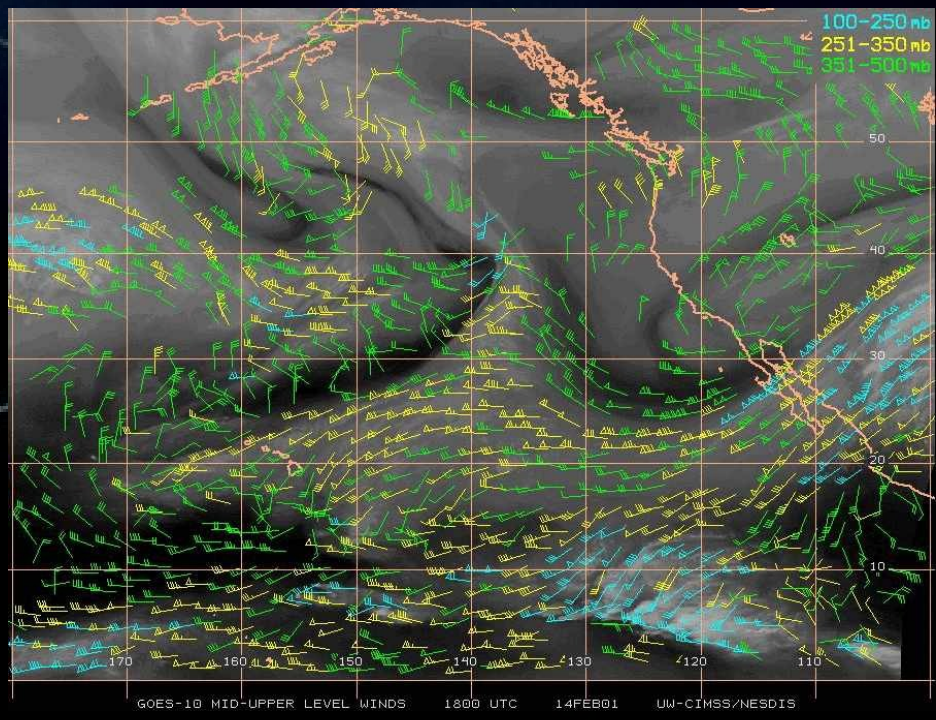
Advantages

- Global coverage except near the poles
- Good coverage in data-void marine areas
- Huge volume of data
- Help define weather systems in three dimensions
- Can view mesoscale events missed by models
- Verification of models
- Assimilation into models
- Improvement expected: more accuracy, better coverage



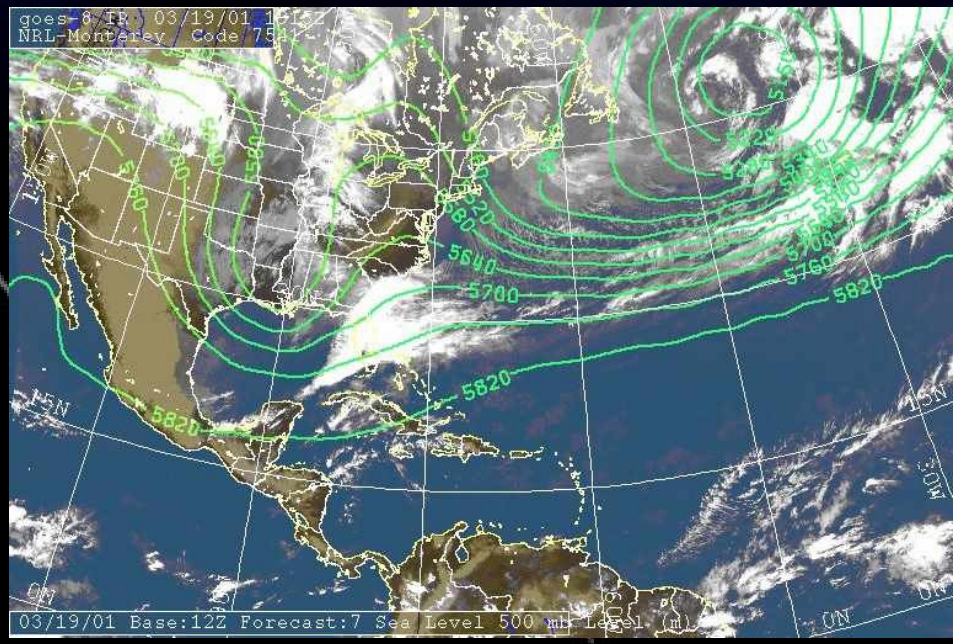
Disadvantages

- Height assignment of wind vectors can be a problem
- Cannot be used in cloud free areas
- Winds not available for the immediate surface due to difficulty in tracking stratus,fog, etc
- Limited to tropical and mid-latitude areas
- Visible winds only available during the day

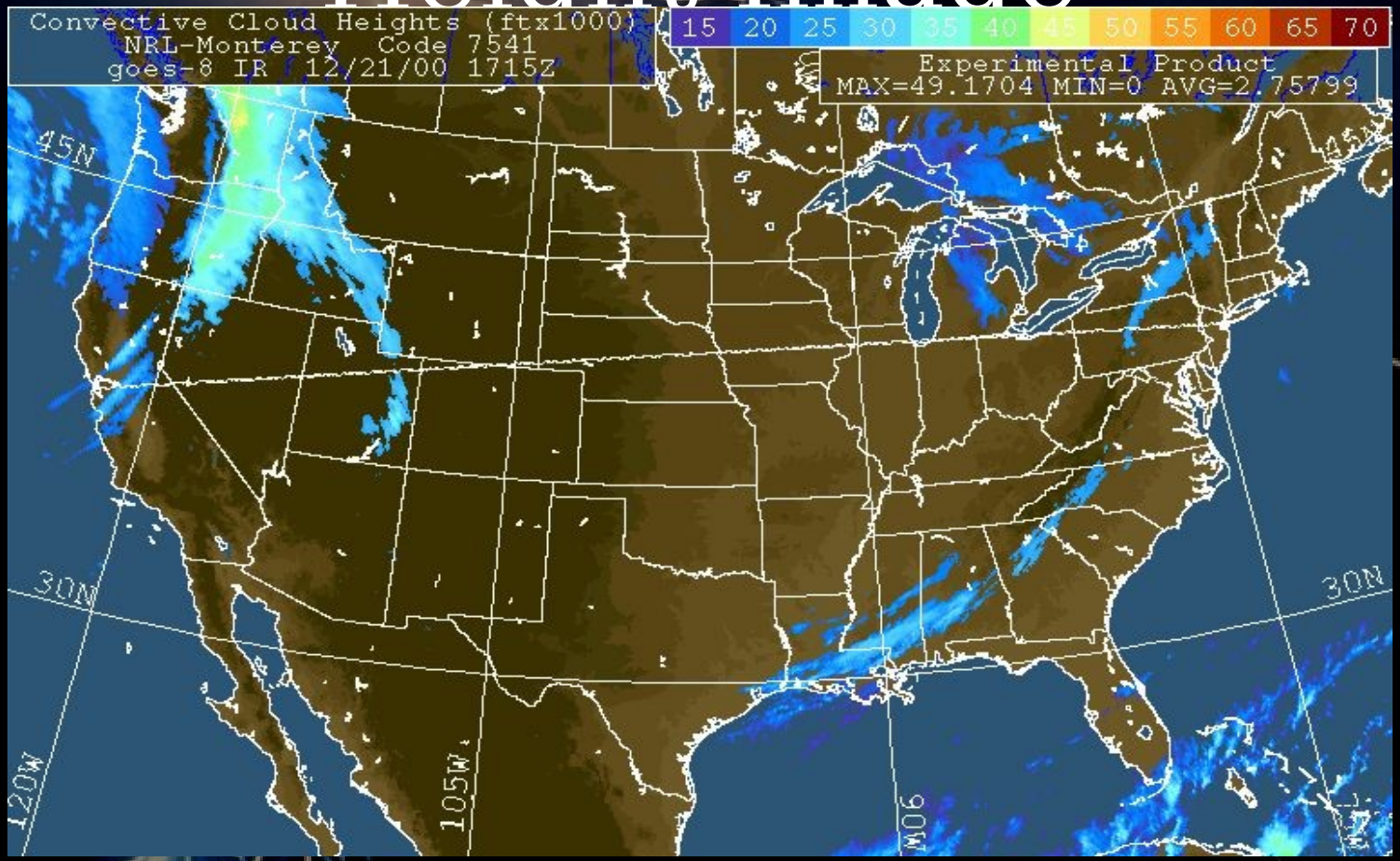


Do Not confuse Geostationary Winds with Model Overlays

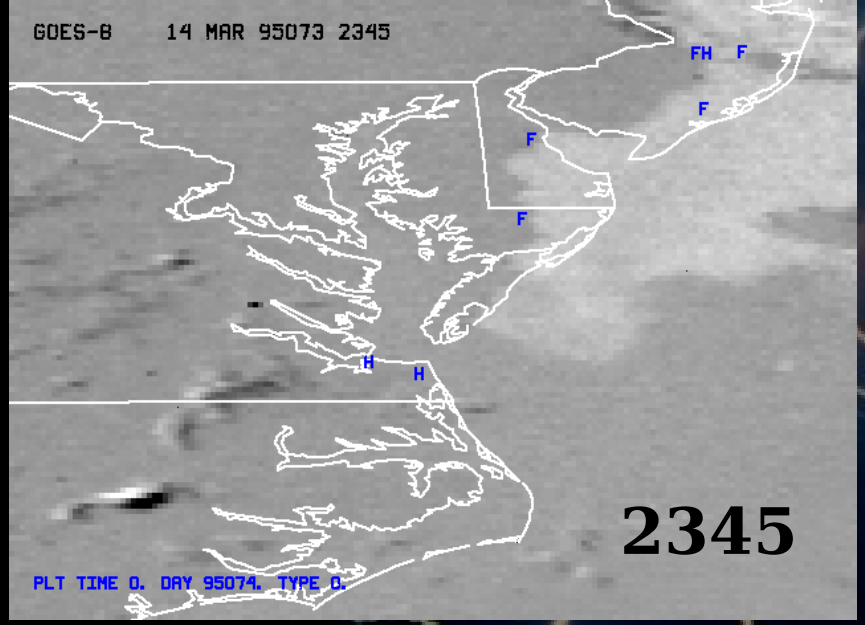
- Geostationary winds are derived from the imagery itself (satellite derived)
- Model overlays use forecast model output overlaid on a satellite image

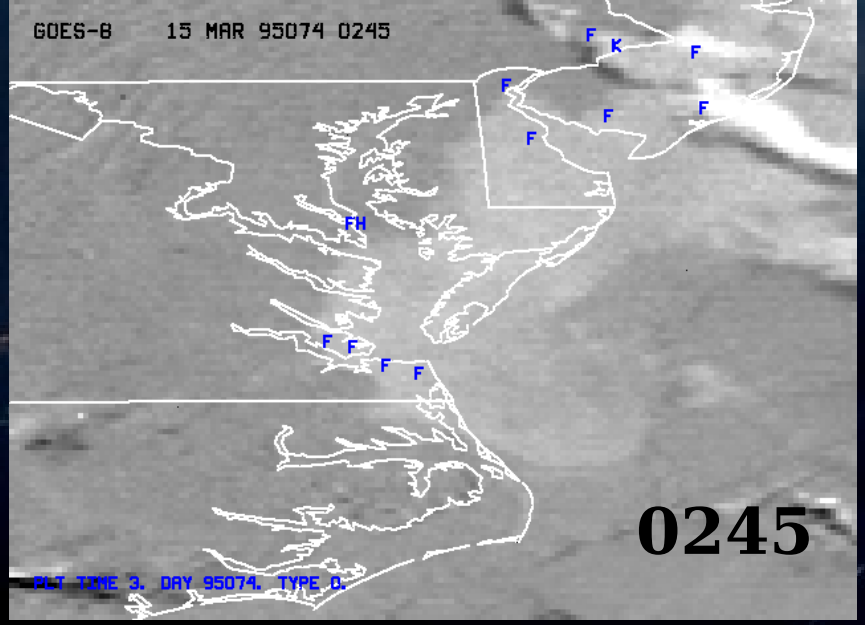


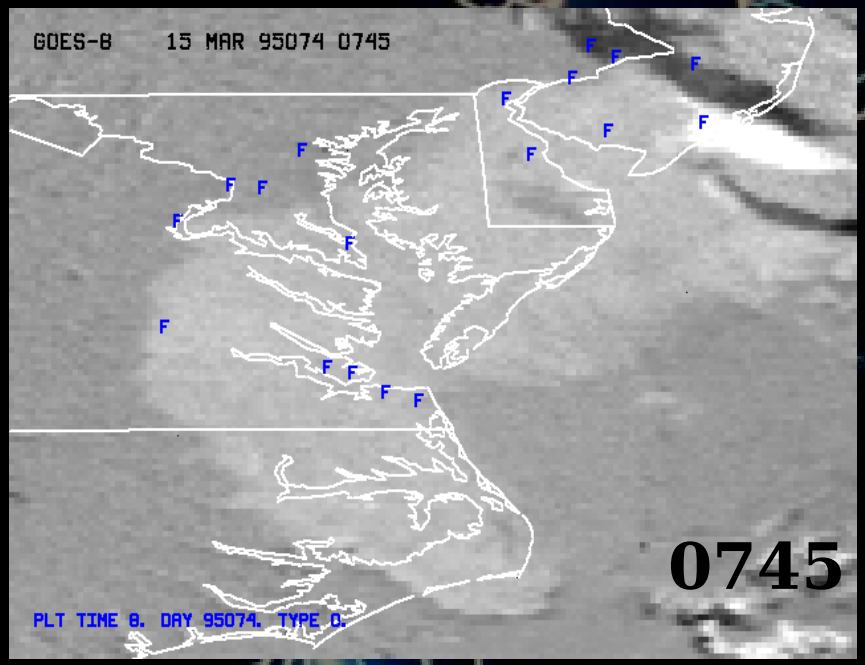
IR/NOGAPS/GOES Cloud Top Height Image

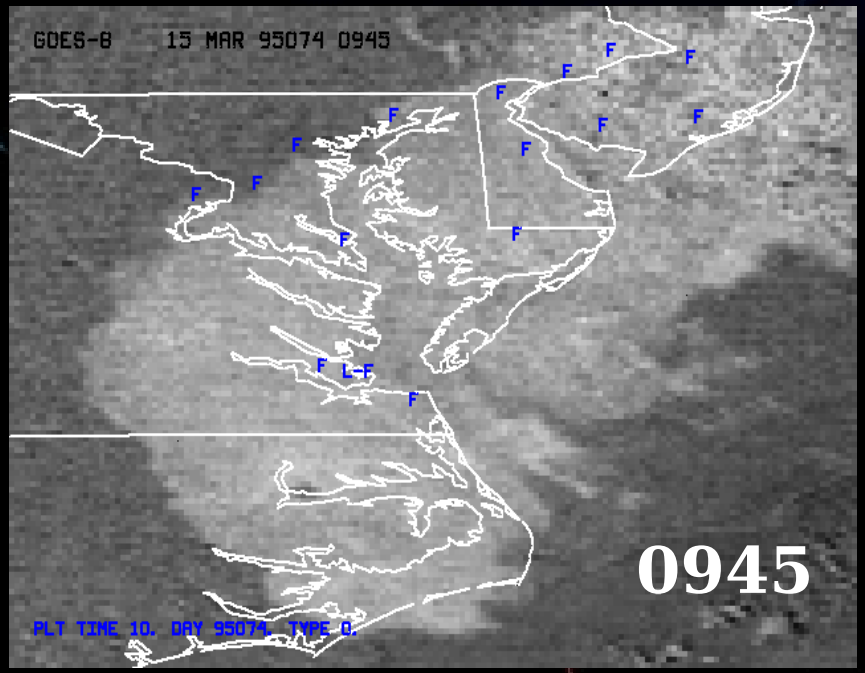


Low Cloud at Night Product


GOES-8 14 MAR 95073 2345
2345
PLT TIME 0. DAY 95074. TYPE 0.


GOES-8 15 MAR 95074 0245
0245
PLT TIME 3. DAY 95074. TYPE 0.


GOES-8 15 MAR 95074 0745
0745
PLT TIME 8. DAY 95074. TYPE 0.


GOES-8 15 MAR 95074 0945
0945
PLT TIME 10. DAY 95074. TYPE 0.

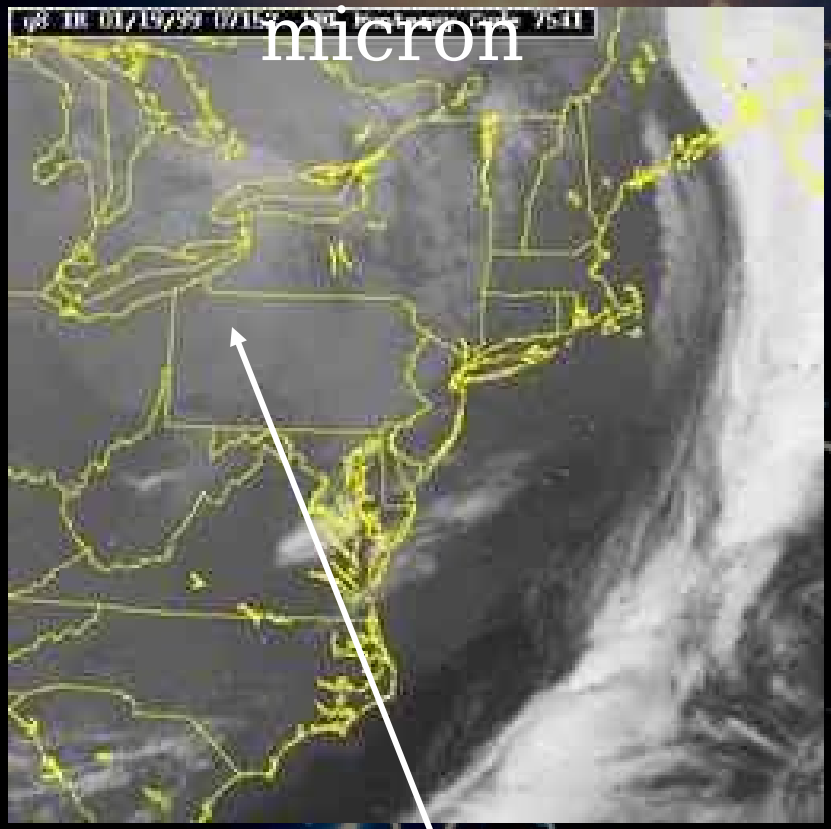
Characteristics of Low Cloud Product

- Multi-spectral product (also known as a bi-spectral product)
- CH4 – CH2 (or longwave IR minus shortwave IR)

  Based on the difference in brightness temperatures over low clouds, due to different cloud emissivities in the two channels
- Allows visualization of stratus/fog at night

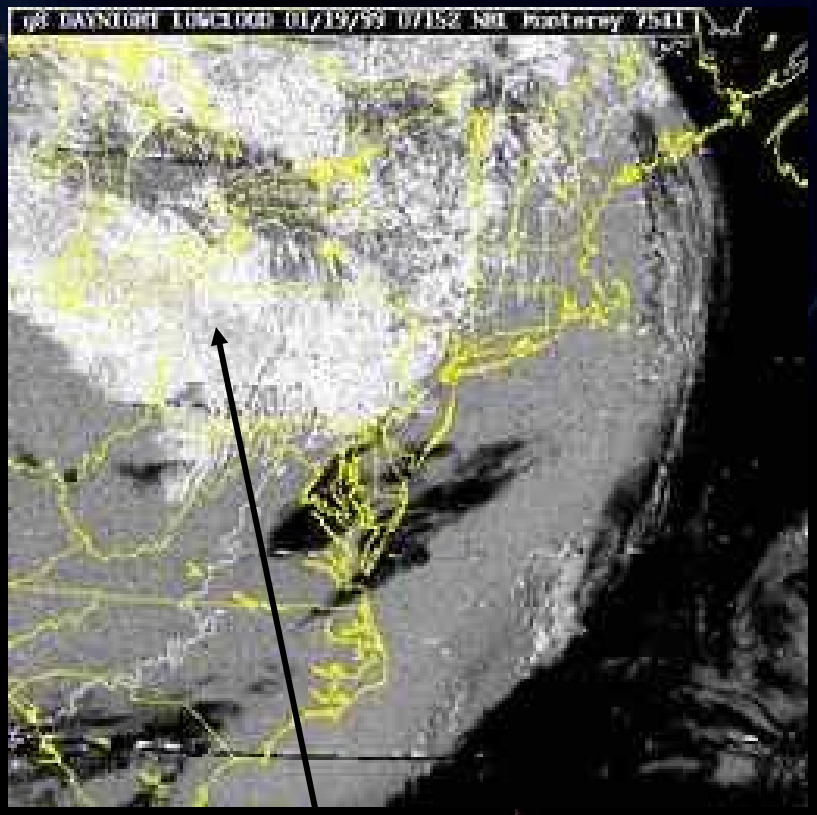
Low Cloud vs. Infrared

Infrared 11 micron



Low clouds hard to see

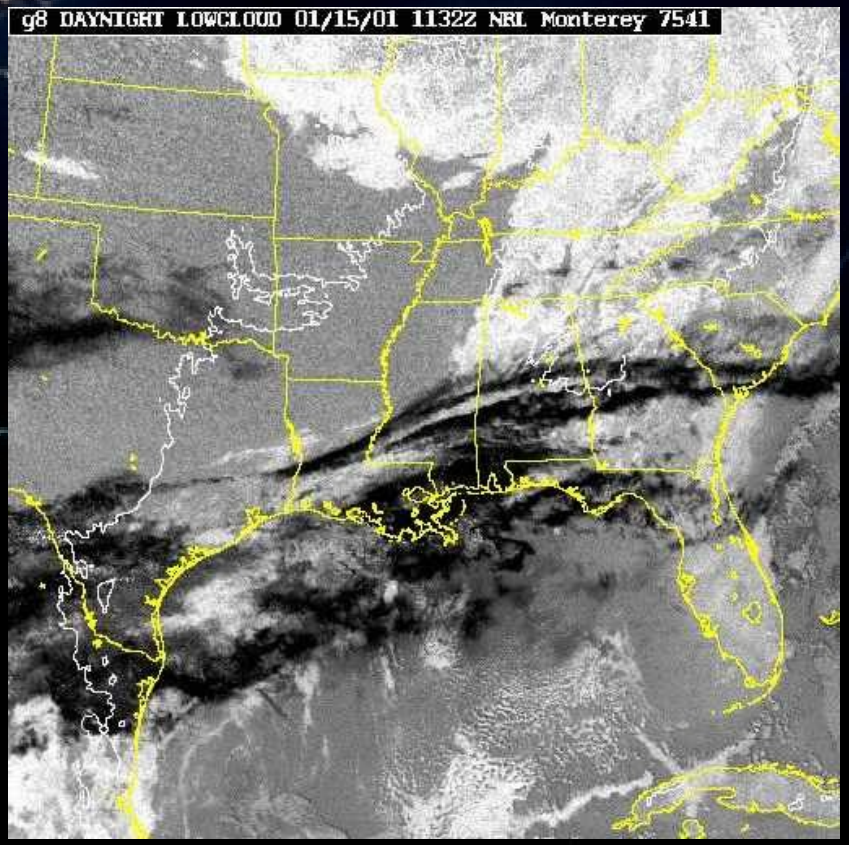
Low Cloud



Low clouds revealed

Advantages

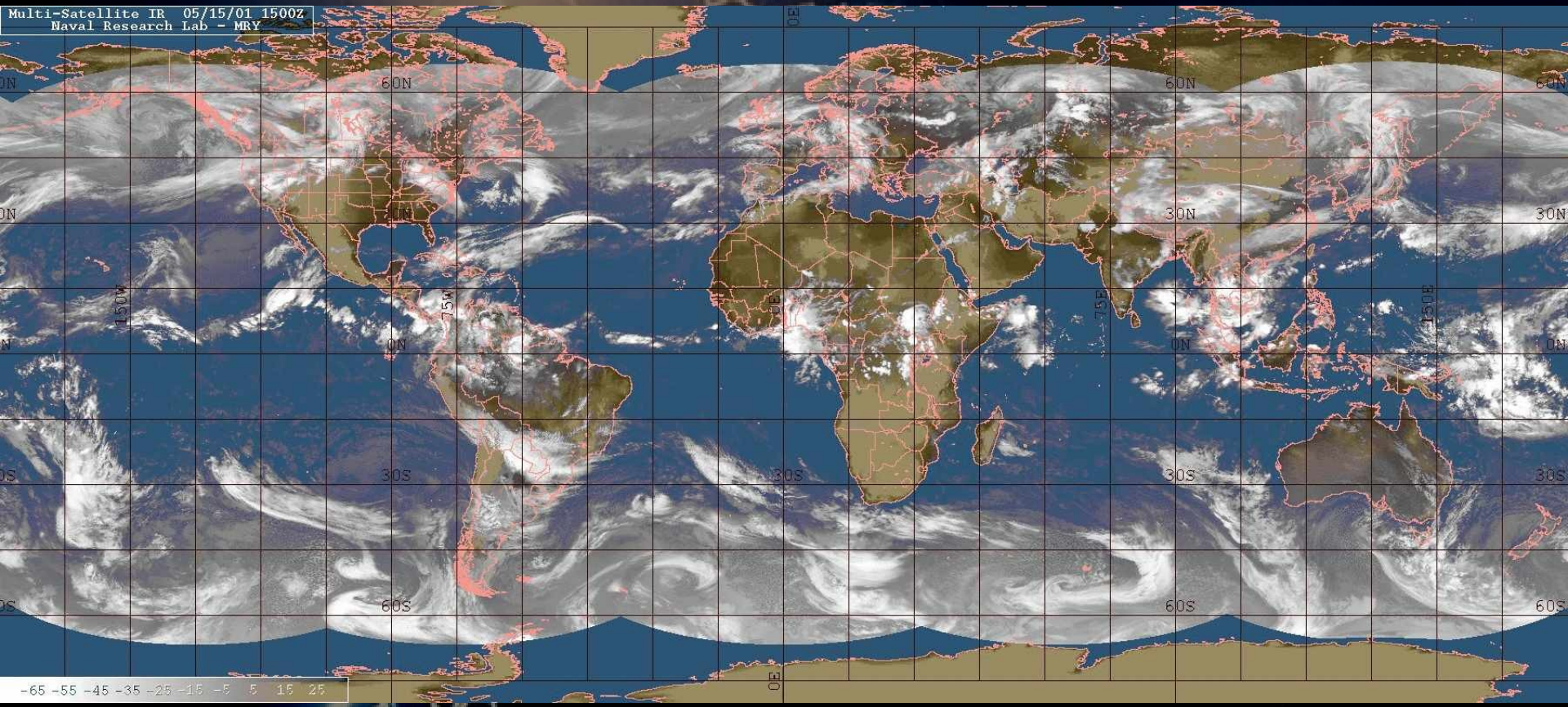
- Nighttime coverage
- Good for unobserved areas (oceans, no surface reports)
- Low clouds always white
- High clouds black



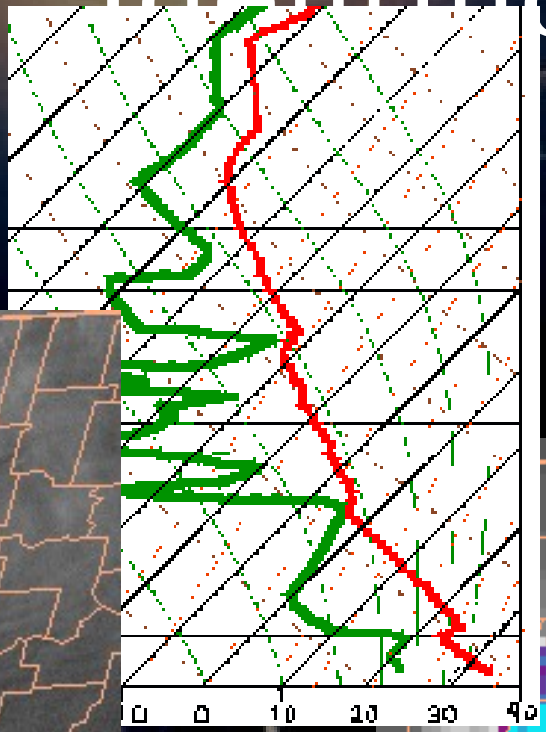
Disadvantages

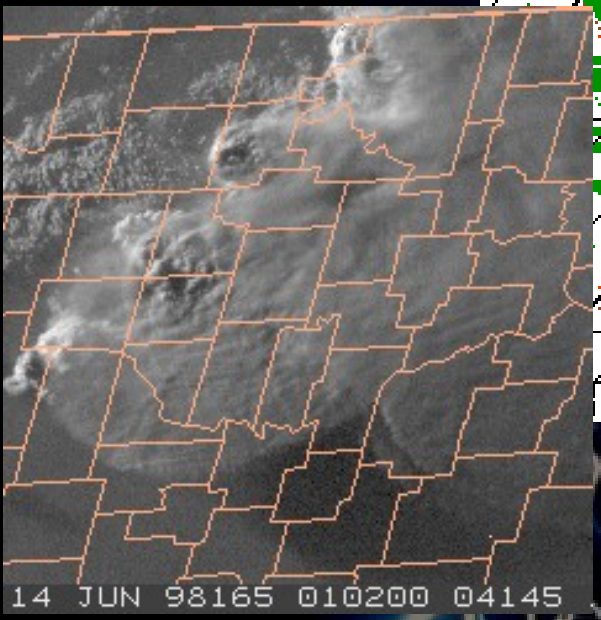
- Cannot distinguish between fog and stratus.
- Nighttime portion of the product is only good for ST, FG, or SC. Does not perform well over cumulus.
- Difficult to discern night high clouds from land.
- 4 km night resolution is not as good as 1 km visible resolution during the day.

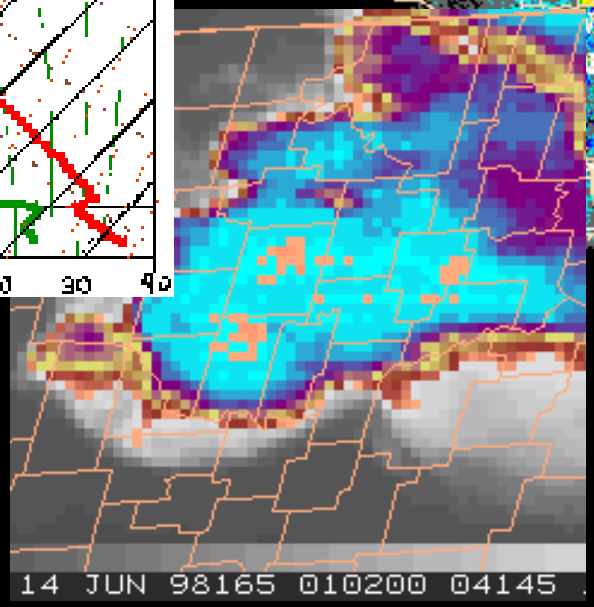
Stitched Imagery

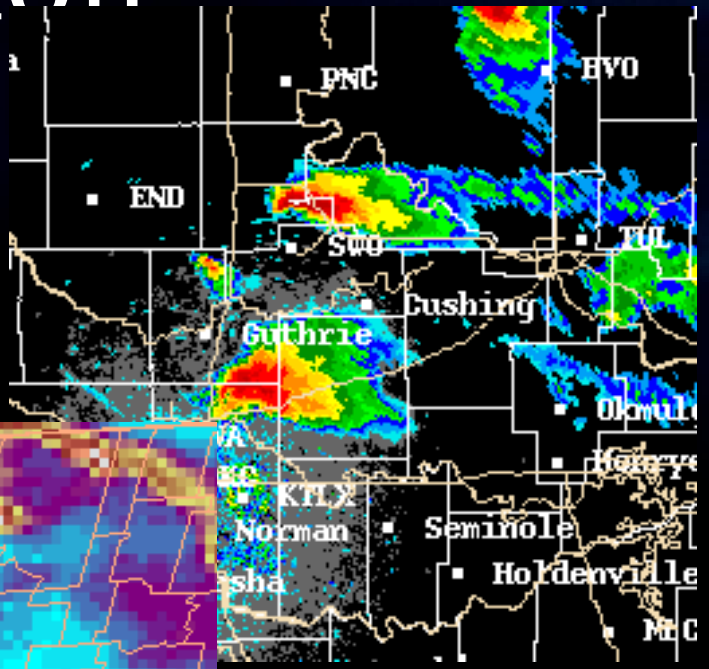


Severe Weather Identification

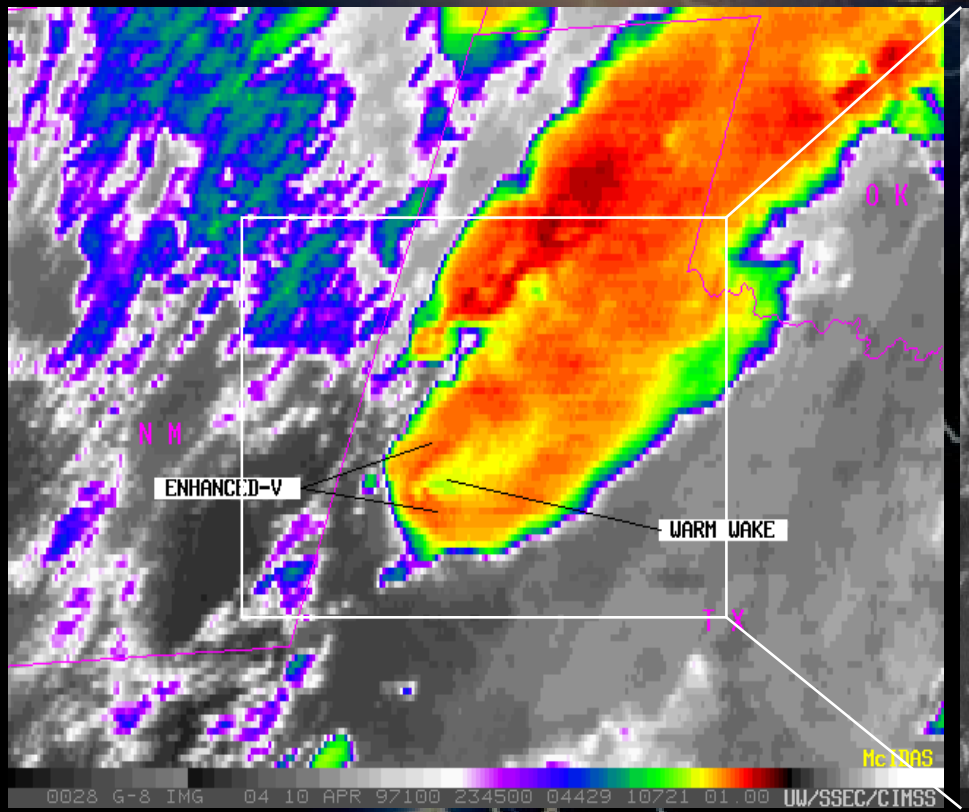


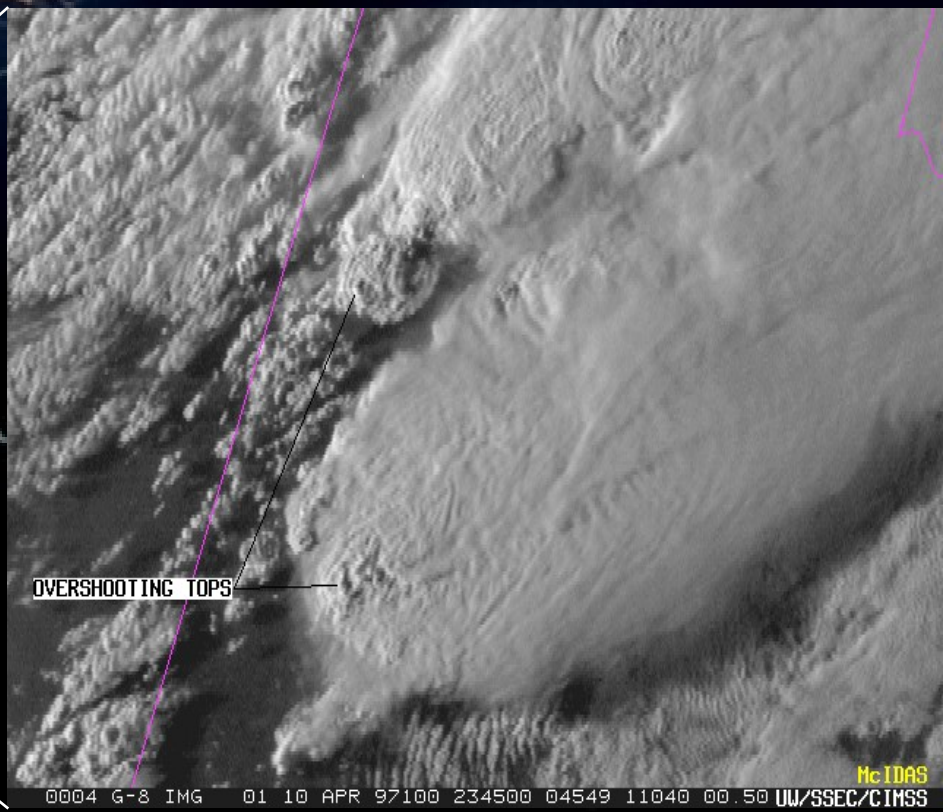






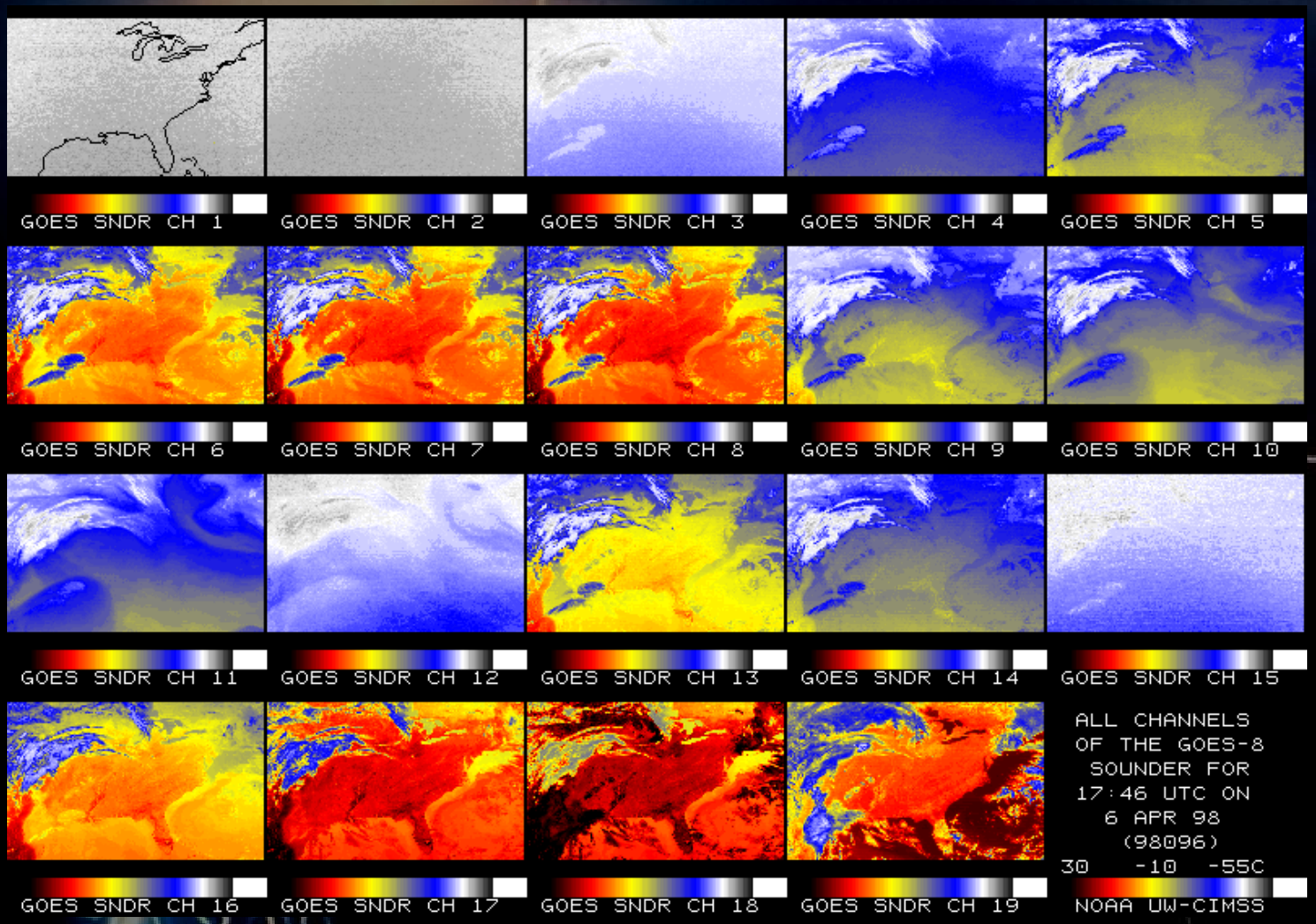
Convective Storm Signatures Enhanced “V”





Obstructions to Vision

GOES Sounder



GOES as Sounder

- GOES Includes Imager and Sounder
- Characteristics
- Channels
  - Weighting function
- Products
  - Skew-T, Total Precipitable Water, LI/CAPE, Cloud Top Pressure
- Model Impact
- Advantages and disadvantages

Characteristics

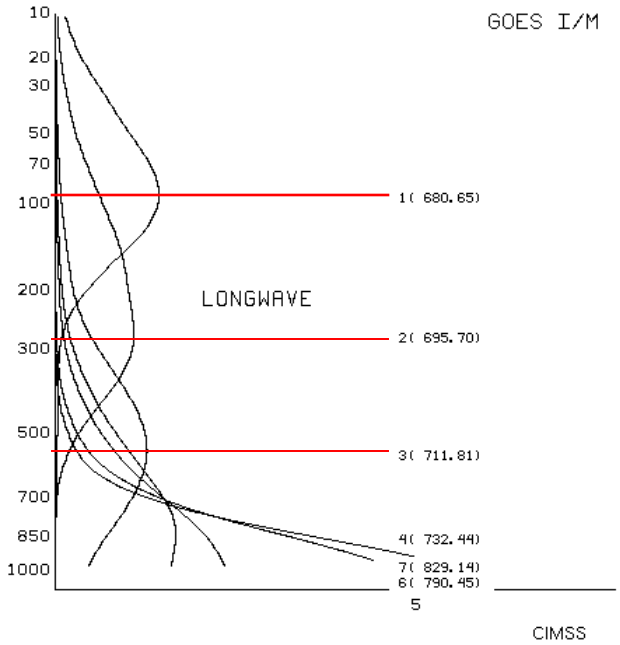
- Spectral resolution: 0.4 to approx. 15μm
- 40 different levels: 1000 mb to 1 mb
- Spatial resolution: 8 km

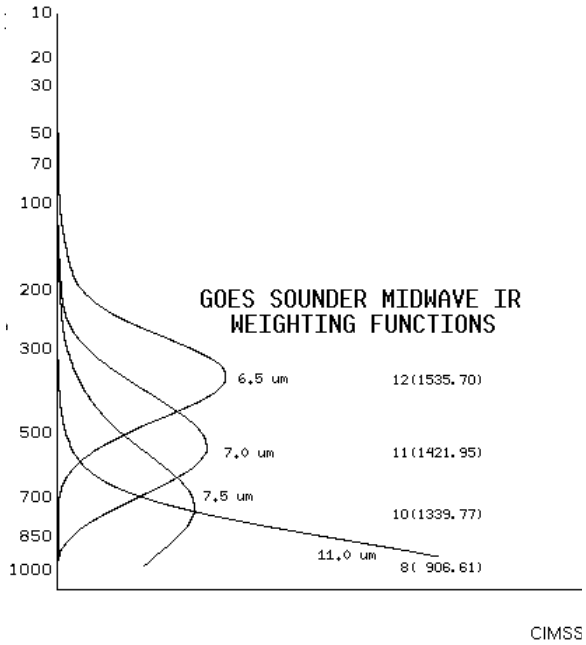
  (compare with an average of 2 RAOB stations per state)
- Volumetric average: over 50 km^2 area
- Temporal resolution: Geo-synchronous sounder products are processed hourly
- Sounder channels: 18 thermal / 1 visible

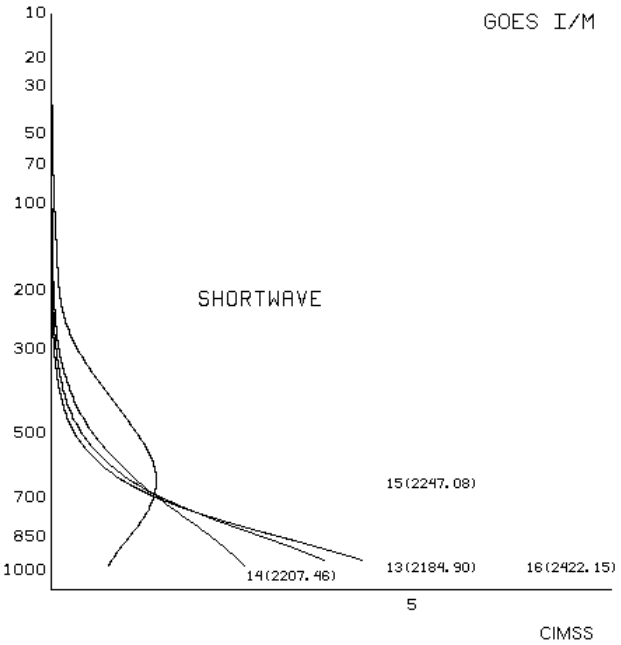
Channels

- Specific atmospheric layer
- Specific weighting function
- Combine data from all channels for soundings
- Soundings not derived in cloudy regions

Weighting Function







Ch 1-6
Ch 13-16

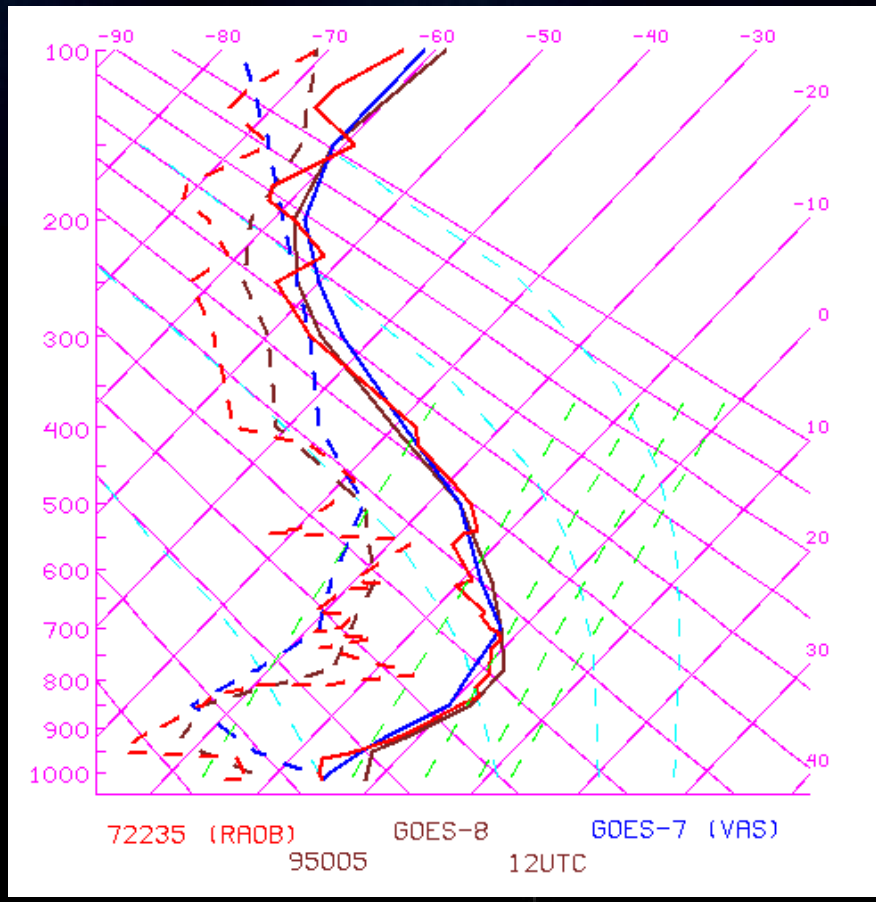
Ch 8, 10-12

Sounder Derived Products

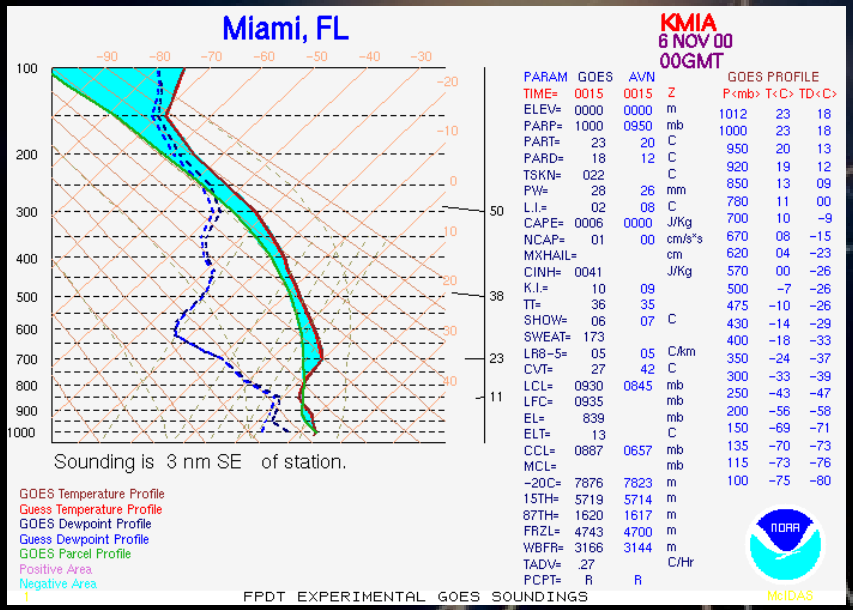
- Soundings
- Lifted Index (LI)
- CAPE
- Total Precipitable Water (TPW)

Soundings

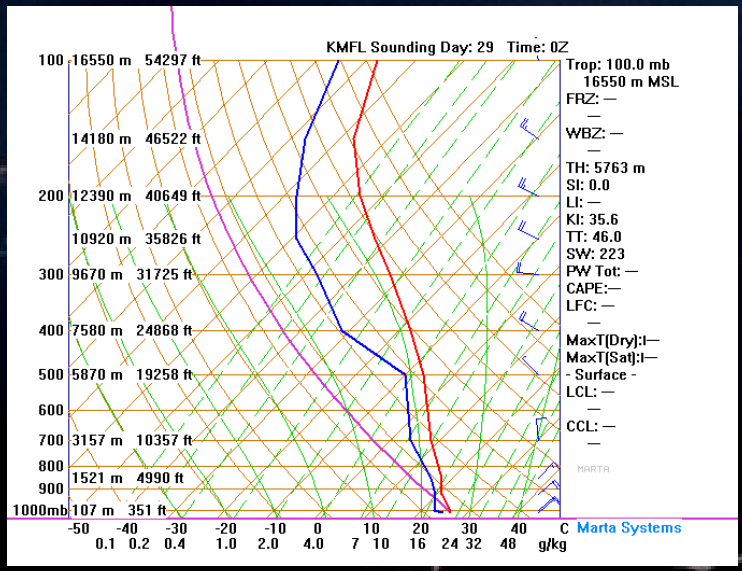
- Clear to partly cloudy skies
- 40 different pressure levels (1000 – 1 mb)
- Averages of values over 50 km^2 (not absolute values)
- 1st guess temp profile obtained from NWS forecast models
- Hourly SFC and SST obs. Help provide surface boundary info
- Vertical moisture profiles at same levels up to 300mb
- GOES sounder profiles are produced hourly



Soundings cont.



PARAM	GOES	AVN		GOES PROFILE P<mb>	T<C>	TD<C>
TIME=	0015	0015	Z			
ELEV=	0000	0000	m	1012	23	18
PARP=	1000	0950	mb	1000	23	18
PART=	23	20	C	950	20	13
PARD=	18	12	C	920	19	12
TSKN=	022		C	850	13	09
PW=	28	26	mm	780	11	00
L.I.=	02	08	C	700	10	-9
CAPE=	0006	0000	J/Kg	670	08	-15
NCAP=	01	00	cm/s^s	620	04	-23
MXHAIL=			cm	570	00	-26
CINH=	0041		J/Kg	500	-7	-26
K.I.=	10	09		475	-10	-26
TT=	36	35		430	-14	-29
SHOW=	06	07	C	400	-18	-33
SWEAT=	173			350	-24	-37
LR8-5=	05	05	C/km	300	-33	-39
CVT=	27	42	C	250	-43	-47
LCL=	0930	0845	mb	200	-56	-58
LFC=	0935		mb	150	-69	-71
EL=	839		mb	135	-70	-73
ELT=	13		C	115	-73	-76
CCL=	0887	0657	mb	100	-75	-80
MCL=			mb			
-20C=	7876	7823	m			
15TH=	5719	5714	m			
87TH=	1620	1617	m			
FRZL=	4743	4700	m			
WBFR=	3166	3144	m			
TADV=	.27		C/Hr			
PCPT=	R	R				

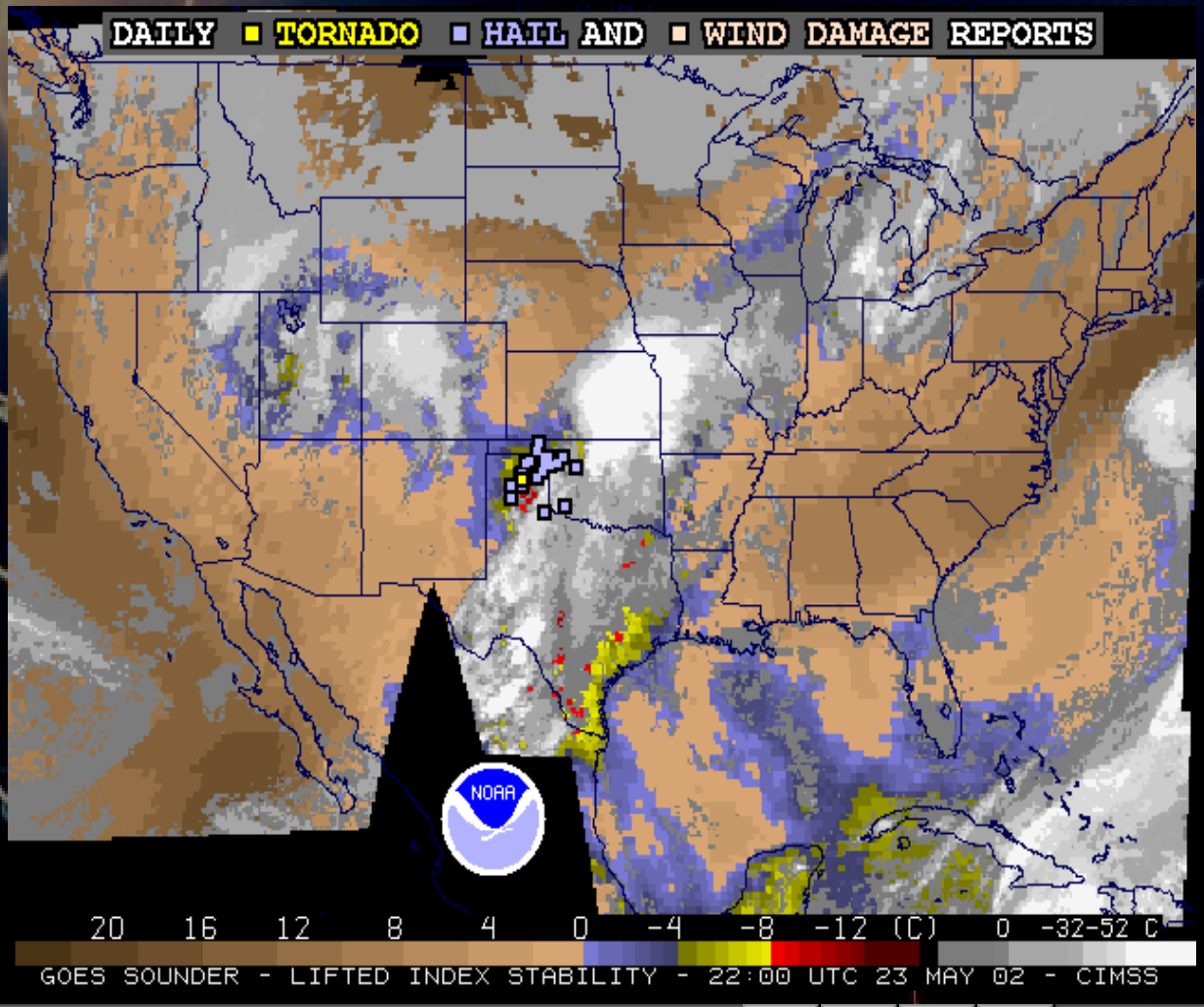


Miami 00z RAOB

- Soundings are used primarily as input to models.
- They are constructed from specific levels and are not as accurate as rawinsondes.
- In particular, the satellite sounding lack accuracy near the surface.
- They may provide an additional tool to the forecaster in data-void areas
- Model (COAMPS) sounding may be better and more timely.

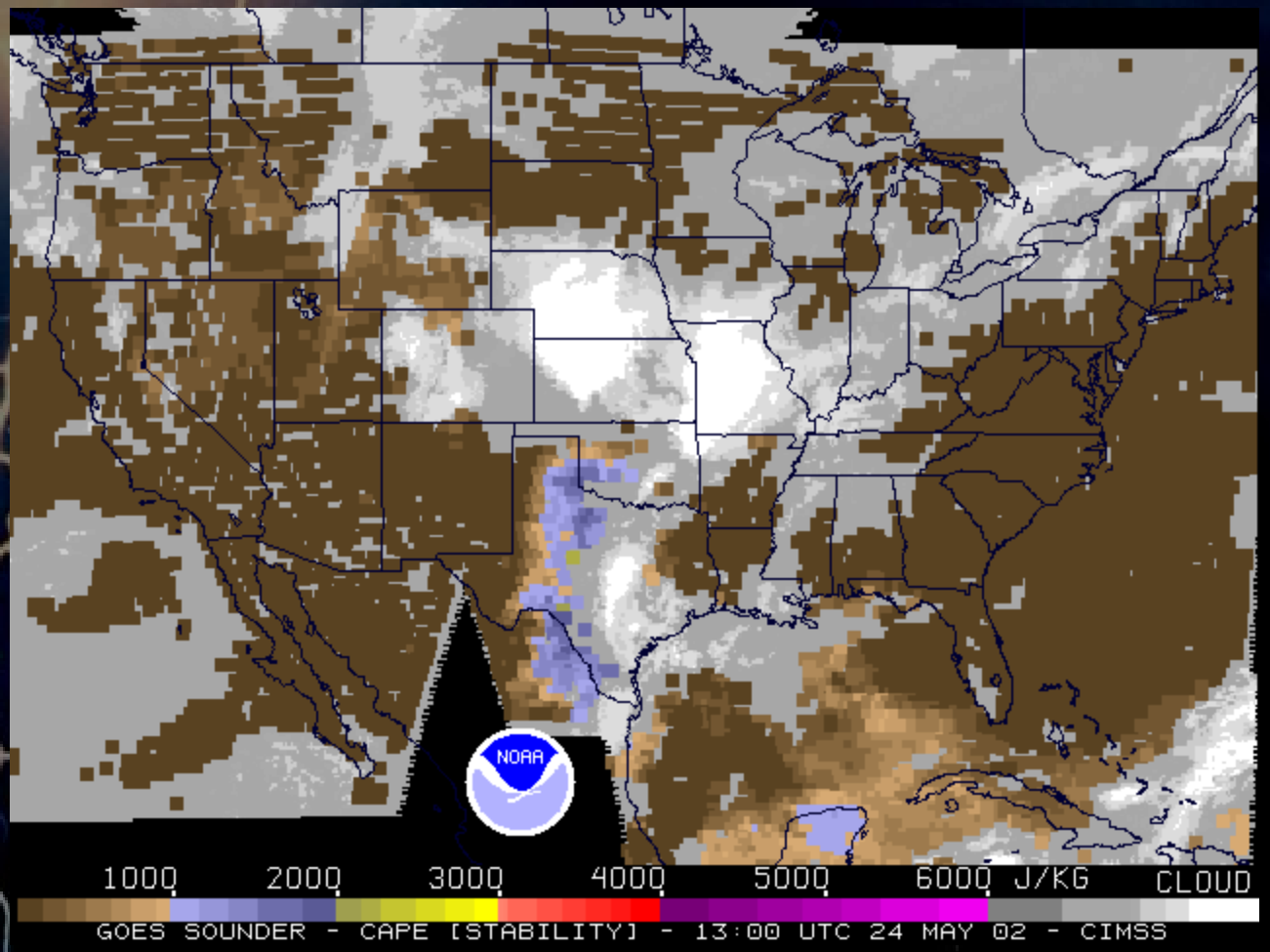
Lifted Index (LI)

- Estimate of atmospheric stability: “Quick look”
- Use looping to monitor stability trends
- Produced hourly @10 km resolution

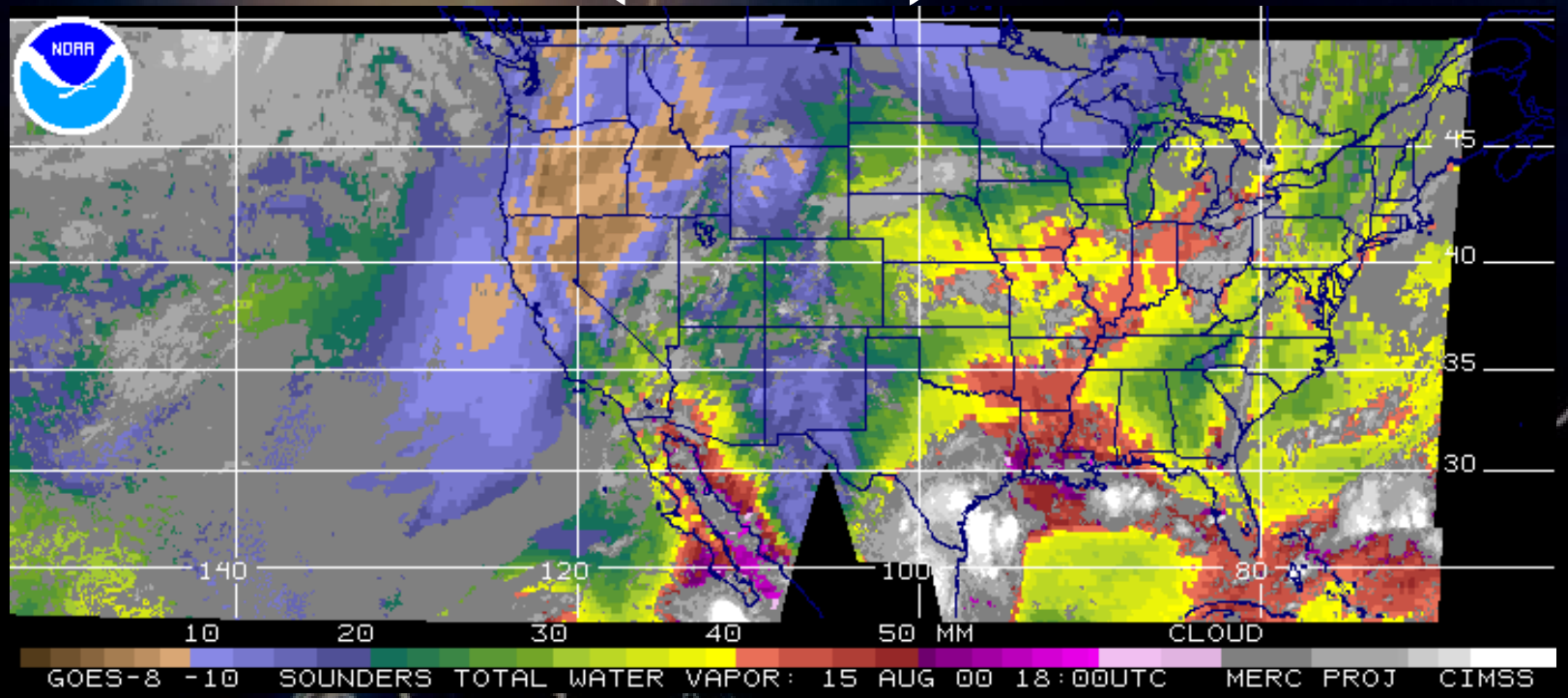

DAILY ▪ TORNADO ▪ HAIL AND ▪ WIND DAMAGE REPORTS
NOAA
20 16 12 8 4 0 -4 -8 -12 (C) 0 -32-52 C
GOES SOUNDER - LIFTED INDEX STABILITY - 22:00 UTC 23 MAY 02 - CIMSS

CAPE

- Like Lifted Index, also a measure of stability
- Use looping to monitor stability trends
- 10 km resolution



Total Precipitable Water (TWP)



- Use looping to monitor drying and moistening trends
- 14 km resolution
- Hourly imagery

Where to find it…

- NOAA/NESDIS
  - http://orbit-net.nesdis.noaa.gov/goes/soundings/
- CIMSS
  - Cooperative Institute for Meteorological Satellite Studies – University of Wisconsin, Madison, WI
  - http://cimss.ssec.wisc.edu/goes
- CIRA
  - Cooperative Institute for Research in the Atmosphere – Colorado State University, Fort Collins, CO
  - http://www.cira.colostate.edu/ramm/rmsdsol/main.html

Model Impact of GOES Sounder

- The primary impact on NOGAPS is from the geostationary winds, which incorporate sounder information (along with imager data).
- Improvement has been noted especially over tropical cyclones.

GOES Sounder

- Advantages
  - Derived products are useful
  - Hourly information
  - Useful for identifying trends (i.e. stability, drying)
  - “Quick” look at an area
  - Valuable for model input

GOES Sounder

- Disadvantages
  - Soundings are not as good as RAOBS – especially near the surface
  - Data is only available in clear or partly cloudy skies
  - Averages information

Summary
Geostationary Satellites

- Characteristics: Altitude, Orbit Configuration, Spatial Resolution
- Operational Satellites
- GOES
  - Imager
  - Sounder

Questions

- APPLICATION: Assign Review Exercise 5.

- EVALUATION: Administer and evaluate Appraisal 302f. Give the Written Test at the end of the unit.